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INSTALLATION RESTORATION PROGRAM

STAGE 3

REMEDIAL INVESTIGATION/FEASIBILITY STUDY

ELMENDORF AIR FORCE BASE, ALASKA

AD-A227 500

PREPARED BY:

BLACK & VEATCH, ENGINEERS-ARCHITECTS

4370 West 109th Street

OVERLAND PARK, KANSAS 66211

MAY 1990

FINAL REPORT

VOLUME 2 OF 6

SECTIONS V - BIBLIOGRAPHY

TEXT

PREPARED FOR:

HEADQUARTERS ALASKAN AIR COMMAND

ELMENDORF AFB, AK

UNITED STATES AIR FORCE

OCCUPATIONAL & ENVIRONMENTAL HEALTH LABORATORY (AFSC)

TECHNICAL SERVICES DIVISION (AFOEHL/TS)

BROOKS AIR FORCE BASE, TEXAS 78235-5501

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USAF CONTRACT NO. F33615-87-D-4021, DELIVERY ORDER NO. 0002

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V. ALTERNATIVE REMEDIAL MEASURES

As a result of the field investigation program, a feasibility study (FS) of alternative remedial measures is required for 7 of the 32 sites investigated at Elmendorf AFB. Alternative remedial measures for Sites D-16, IS-1, SP-5/5A, SP-7/10 and SP-15 are developed and evaluated in this section.

The FS is completed in 3 phases: Phase I - development of alternatives, Phase II - screening of the alternatives, and Phase III - detailed analysis of alternatives. During Phase I, various technologies and process options are identified, screened, and then grouped into remedial alternatives. The alternatives which are developed in Phase I are screened in Phase II based on effectiveness, implementability, and cost. Those alternatives which remain after the Phase II evaluation are described in detail and evaluated based on the following criteria: technical feasibility, institutional requirements, environmental impacts, public health impacts, and cost.

This Alternative Remedial Measures section was prepared in accordance with AFOEHL/TS's Handbook to Support the Installation Restoration Program Statements of Work for Remedial Investigation/Feasibility Study. The March 1988, Draft EPA document titled Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA was also used in preparing this section. The format for this section is a result of incorporating requirements of the EPA draft guidance document with the AFOEHL/TS report format.

5.1 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS)

Consistent with the Superfund Amendments and Reauthorization Act (SARA), the remedial action alternatives developed in an FS should address legally applicable or relevant and appropriate requirements

(ARARs). These ARARs may be any standard, requirement, criteria, or limitation under any Federal environmental law, or any State environmental or facility siting law that is more stringent than the corresponding Federal standard, requirement, criteria, or limitation.

EPA's Interim Guidance on Compliance with ARARs establishes how requirements of Federal and State laws are generally identified and applied to remedial actions at hazardous waste sites. CERCLA as amended by SARA requires that Federal facility remedial actions comply with requirements or standards under Federal and State environmental laws. Therefore, ARARs are pertinent to the sites at Elmendorf AFB even though they are not Superfund sites. ARARs are identified by applying a two-tier test to first determine if the requirement is applicable and then, if it is not applicable, to determine if it is relevant and appropriate. The guidance defines "applicable" and "relevant and appropriate" requirements as:

- Applicable requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or State law that specifically address a hazardous substance, pollutant or contaminant, remedial action, location, or other circumstances at a CERCLA site.

- Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or State law that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the

CERCLA site that their use is well suited to the particular site. For example, requirements may be relevant and appropriate if they would be "applicable" but for jurisdictional restrictions associated with the requirements.

The judgement as to the relevance and appropriateness of a requirement can be made based on several factors including the characteristics of the remedial action, the hazardous substances in question, or the physical situation of the site. Only portions of requirements may be relevant and appropriate for a remedial action; however, any requirement or portion thereof that is determined to be relevant and appropriate must be complied with to the same degree as if it were applicable.

There are 3 types of ARARs. The first type are chemical-specific ARARs which establish health- or risk-based concentration limits for the various environmental media. The chemical-specific ARARs may set a level of cleanup or discharge. The second type, location-specific ARARs, set limitations on remedial activities as a result of the site characteristics. These can include restrictions for activities performed in wetlands, flood plains, and historical sites. The third type are action-specific ARARs which establish controls on the remedial activities which are a part of the remedial solution.

The potential ARARs identified for the 7 Elmendorf AFB sites are described hereinafter.

5.1.1 Chemical-Specific ARARs

This section presents both Federal and State of Alaska chemical specific ARARs. Chemical-specific ARARs are usually health- or risk-based numerical values or methodologies which, when applied to

site specific conditions, result in the establishment of numerical values. These values establish the acceptable amount or concentration of a chemical that may be found in, or discharged to the environment, unless the chemical is found naturally in the environment at greater levels.

5.1.1.1 Drinking Water Standards

Table 5-1 identifies both Federal (Safe Drinking Water Act) and state maximum contaminant levels (MCL) for public water systems for contaminants detected at the 7 sites (evaluated in this FS) during the 1988 field investigation program.

The state drinking water standards are found in Title 18, Alaska Administrative Code, Chapter 80. The federal drinking water standards are found in the Safe Drinking Water Act.

State secondary MCLs and federal maximum contaminant level goals (MCLG) are health goals for public drinking water systems. These levels are potentially relevant and appropriate standards. These values mainly affect the aesthetic qualities of drinking water or are based upon chronic toxicity data. Substances considered to be probable human carcinogens are set at the zero level. Table 5-2 identifies state MCL and federal MCLGs for contaminants detected at the 7 sites during the 1988 field investigation program.

5.1.1.2 Water Quality Standards

Title 18 of the Alaska Administrative Code, Chapter 70 sets water quality standards for state waters. Chapter 70 specifies the limits that may not be exceeded in a water body as a result of human actions. Short-term variances can be granted by the Department of Environmental Conservation for a one-time, temporary activity that is a nonpoint

TABLE 5-1. FEDERAL DRINKING WATER STANDARDS

Chemical[1]	MCL	Units
Arsenic	0.05	mg/L
Barium	1.0	mg/L
Benzene	5.0	ug/L
Cadmium	0.01	mg/L
Chromium	0.05	mg/L
Lead	0.05	mg/L
Total Mercury	0.002	mg/L
1,1,1-Trichloroethane	200	ug/L
Ethylbenzene	700	ug/L
Toluene	2,000	ug/L
Xylene(2)	10,000	ug/L

(1) Only chemicals detected during the 1988 field investigation program at the 7 sites evaluated in this FS are listed in this table.

(2) State of Alaska proposed MCL for xylene is 440 ug/L.

TABLE 5-2. SECONDARY DRINKING WATER STANDARDS AND MCLGS

Chemical*	Concentration	Units
Copper	1.0 (1)	mg/L
Iron	0.3 (1)	mg/L
Manganese	0.05 (1)	mg/L
Sulfate	250 (1)	mg/L
Total Dissolved Solids	500 (1)	mg/L
Zinc	5 (1)	mg/L
1,1,1-Trichloroethane	0 (2)	ug/L
Xylene (Total)	0.44 (2)	ug/L

(1) State of Alaska secondary maximum contaminant concentration standards.

(2) Safe Drinking Water Act maximum contaminant level goal.

*Only chemicals detected during the 1988 field investigation program at the 7 sites evaluated in this FS are listed in this table.

source of water pollution (Chapter 70.015). Table 5-3 identifies the Alaska water quality standards for contaminants detected at the 7 sites during the 1988 field investigation program.

The Clean Water Act (CWA) requires EPA to publish water quality criteria for specific "pollutants, or their byproducts." EPA develops two kinds of water quality criteria one for the protection of human health and the other for protection of aquatic life. Federal water quality criteria may be relevant and appropriate to cleanup of surface and groundwaters. Table 5-4 identifies the federal water quality standards for compounds detected during the 1988 field investigation program at the 7 sites.

5.1.2 Location-Specific ARARs

Location-specific ARARs are restrictions placed on the concentration of hazardous substances or the conduct of activities solely because they are in specific locations. Table 5-5 identifies location-specific requirements established under several statutes that are potential ARARs.

5.1.3 Action-Specific ARARs

Action-specific ARARs are usually technology or activity based requirements, or limitations on actions taken with respect to hazardous wastes. These requirements are triggered by the particular remedial activities that are selected to accomplish a remedy. The action specific requirements do not in themselves determine the remedial alternatives; rather, they indicate how a selected alternative must be achieved. Potential action-specific ARARs for the five sites are presented in this section. The action-specific ARARs for each alternative will differ depending on the technologies employed to meet the remedial action objectives. The actual

TABLE 5-3. ALASKA WATER QUALITY STANDARDS

Freshwater Uses	Dissolved Inorganic Substances
Water Supply (drinking, culinary, and food processing)	Total dissolved solids (TDS) from all sources shall not exceed 500 mg/L. Neither chlorides nor sulfates shall exceed 200 mg/L.
Water Supply (agriculture, including irrigation and stock watering)	TDS shall not exceed 1,000 mg/L, absorption ratio less than 2.5, sodium percentage less than 60 percent, residual carbonate less than 1.25 mg/L, and boron less than 0.03 mg/L.
Water Recreation (contact recreation)	N/A
Water Recreation (secondary recreation)	N/A
Growth and Propagation of Fish, Shellfish other Aquatic Life and Wildlife	TDS shall not exceed a maximum of 1,500 mg/L, including natural conditions; increase in TDS shall not exceed one-third of the concentration of the natural condition of the body of water.

TABLE 5-3 (continued). ALASKA WATER QUALITY STANDARDS

Freshwater Uses	Petroleum Hydrocarbons, Oil and Grease
Water Supply (drinking, culinary, and food processing)	Shall not cause a visible sheen upon the surface of the water. Shall not exceed concentrations which individually or in combination impart odor or taste as determined by organoleptic test.
Water Supply (agriculture, including irrigation and stock watering)	Shall not cause a visible sheen upon the surface of the water.
Water Recreation (contact recreation)	Shall not cause a film, sheen, or discoloration on the surface or floor of the water body or adjoining shorelines. Surface waters shall be virtually free from floating oils.
Water Recreation (secondary recreation)	Shall not cause film sheen or discoloration on the surface or floor of the water body or adjoining shorelines. Surface waters shall be virtually free from floating oils.
Growth and Propagation of Fish, Shellfish other Aquatic Life and Wildlife	Total hydrocarbons in the water column shall not exceed 15 ug/L, or 0.01 times the lowest measured continuous flow 96 hour LC50 for life stages in a particular location, whichever concentration is less. Total hydrocarbons in the water column shall not exceed 10 ug/L, or 0.01 times the lowest measured continuous flow 96 hour LC50 for life stages is species identified by the department as the most sensitive, biologically important species in a particular location, whichever concentration is less. Concentrations of hydrocarbons, animal fats, or vegetable oils in the sediment shall not cause a film, sheen, or discoloration on the surface or floor of the water body or adjoining shorelines. Surface waters shall be virtually free from floating oils.

TABLE 5-3 (continued). ALASKA WATER QUALITY STANDARDS

Freshwater Uses	Toxic and Other Deleterious Organic and Inorganic Substances
Water Supply (drinking, culinary, and food processing)	Substances shall not exceed Alaska Drinking Standards (118 AAC 80) or EPA Quality Criteria for Water as applicable to substance.
Water Supply (agriculture, including irrigation and stock watering)	Same as where contact with a product destined for subsequent human consumption is present. Same as Growth and Propagation of Fish, Shellfish Other Aquatic Life and Wildlife or Federal Water Pollution Control Administration, Water Quality Criteria (WOC/FWPCA) as applicable to substances for stockwaters, concentrations for irrigation waters shall not exceed WOC/FWPCA or WOC 1972.
Water Recreation (contact recreation)	Substances shall not exceed Alaska Drinking Water Standards (118 AAC 80) or EPA Quality Criteria for Water as applicable to substance.
Water Recreation (secondary recreation)	Substances shall not be present which pose hazards to incidental human contact.
Growth and Propagation of Fish, Shellfish other Aquatic Life and Wildlife	Substances shall not individually or in combination exceed 0.01 times the lowest measured 96 hour LC50 for life stages of species identified by the department as being the most sensitive, biologically important to the location, or exceed criteria cited in EPA Quality Criteria for Water (118 AAC 80) whichever concentration is less. Substances shall not be present or exceed concentrations which individually or in combination impart undesirable odor or taste to fish or other acquatic organisms as determined by either bioassay or organoleptic tests.

TABLE 5-4. CWA WATER QUALITY CRITERIA

Contaminant*	CWA Water Quality Criteria for Protection of Human Health		CWA Ambient Water Quality Criteria for Protection of Aquatic Life	
	Water and Fish Ingestion (mg/L)	Fish Consumption Only (mg/L)	Freshwater Acute/Chronic (mg/L)	Marine Acute/Chronic (mg/L)
Arsenic and Compounds	2.2×10^{-6}	1.8×10^{-5}		
Barium and Compounds	1.0			
Benzene	6.6×10^{-4}	5.3×10^{-4}	5.3	
Beryllium and Compounds	6.8×10^{-6}	1.2×10^{-4}	$0.1/5.3 \times 10^{-3}$	
Cadmium and Compounds	1.0×10^{-2}		$3.9 \times 10^{-3}/1.1 \times 10^{-3}$	$4.3 \times 10^{-2}/9.3 \times 10^{-2}$
Copper and Compounds			$1.8 \times 10^{-2}/1.2 \times 10^{-2}$	$2.9 \times 10^{-3}/2.9 \times 10^{-3}$
Cyanides	2×10^{-1}		$2.2 \times 10^{-2}/5.2 \times 10^{-3}$	$1.0 \times 10^{-3}/1.0 \times 10^{-3}$
Ethylbenzene	1.4	3.3	32	4.3×10^{-4}
Lead and Compounds	5.0×10^{-2}		$8.0 \times 10^{-2}/3.2 \times 10^{-3}$	$0.1/5.6 \times 10^{-3}$
Mercury and Compounds	1.4×10^{-4}	1.5×10^{-4}	$2.4 \times 10^{-3}/1.2 \times 10^{-5}$	$2.1 \times 10^{-3}/2.5 \times 10^{-5}$
Nickel and Compounds	1.3×10^{-3}	1.0×10^{-1}	$1.4/1.6 \times 10^{-1}$	$7.5 \times 10^{-2}/8.3 \times 10^{-3}$
Toluene	14	420	17	6.3/5.0
Trichlorinated Ethanes			18	
Zinc and Compounds			$1.3 \times 10^{-1}/1.1 \times 10^{-1}$	$9.6 \times 10^{-2}/8.6 \times 10^{-2}$
1,1,1-Trichloroethane	18	1,000	31	2.0×10^{-1}

*Contaminants detected at the five sites during the 1988 field investigation program are listed in this table.

TABLE 5-5. LOCATION-SPECIFIC POTENTIALLY APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Location	Requirement	Prerequisite	Citation
Within 61 meters (200 feet) of a fault displaced in Holocene time	New treatment, storage, or disposal of hazardous waste prohibited	RCRA hazardous waste; treatment, storage, or disposal	40 CFR 264.18(a)
Within 100-year floodplain	Facility must be designed, constructed, operated, and maintained to avoid washout	RCRA hazardous waste; treatment, storage, or disposal	40 CFR 264.18(b)
Within floodplain	Action to avoid adverse effects, minimize potential harm, restore and preserve natural and beneficial values	Action that will occur in a floodplain, i.e., lowlands, and relatively flat areas adjoining inland and coastal waters and other flood prone areas	Protection of floodplains, (40 CFR 6, Appendix A); Fish and Wildlife Coordination Act (16 USC 661 et seq.); 40 CFR 6.302
Within area where action may cause irreparable harm, loss, or destruction of significant artifacts	Action to recover and preserve artifacts	Alteration of terrain that threatens significant scientific, prehistorical, historical or archaeological data	National Historical Preservation Act (16 USC Section 469); 36 CFR Part 65
Historic project owned or controlled by Federal agency	Action to preserve historic properties; planning of action to minimize harm to National Historic Landmarks	Property included in or eligible for the National Register of Historic Places	National Historic Preservation Act, Section 106 (16 USC 470 et seq.); 36 CFR Part 800
Critical habitat upon which endangered species or threatened species depends	Action to conserve endangered species or threatened species, including consultation with the Department of Interior	Determination of presence of endangered or threatened species	Endangered Species Act of 1973 (16 USC 1531 et seq.); 50 CFR Part 200, 50 CFR Part 402 Fish and Wildlife Coordination Act (16 USC 661 et seq.); 33 CFR Parts 320-330
Wetlands	Action to prohibit discharge of dredged or fill material into wetlands without permit	Wetlands as defined in U.S. Army Corps of Engineers regulations	Clean Water Act section 404; 40 CFR Parts 230, 33 CFR Parts 320-330.
	Action to avoid adverse effects, minimize potential harm, and preserve and enhance wetlands, to the extent possible	Action involving construction of facilities or management of property in wetlands, as defined by 40 CFR Part 6, Appendix A, section 4 (j)	40 CFR Part 6, Appendix A
Wilderness area	Area must be administered in such a manner as will leave it unimpaired as wilderness and to preserve its wilderness	Federally-owned area designated as wilderness area	Wilderness Act (16 USC 1131 et seq.); 50 CFR 35.1 et seq.

TABLE 5-5 (Continued). LOCATION-SPECIFIC POTENTIALLY APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Location	Requirement	Prerequisite	Citation
Wildlife refuge	Only actions allowed under the provisions of 16 USC Section 668dd(c) may be undertaken in areas that are part of the National Wildlife Refuge System	Area designated as part of National Wildlife Refuge System	16 USC 668dd _et_ _seq_.; 40 CFR Part 27
Area affecting stream or river	Action to protect fish or wildlife	Diversion, channeling or other activity that modifies a stream or river and affects fish or wildlife	Fish and Wildlife Coordination Act (16 USC 661 _et_ _seq_.); 40 CFR 6.302
Within area affecting national wild, scenic, or recreational river	Avoid taking or assisting in action that will have direct adverse effect on scenic river	Activities that affect or may affect any of the rivers specified in section 1276(a)	Wild and Scenic Rivers Act (16 USC 1271 _et_ _seq_. section 7 (a)); 40 CFR 6.302(a)
Within coastal zone	Conduct activities in manner consistent with approved State management programs	Activities affecting the coastal zone including lands therein and thereunder and adjacent shorelands	Coastal Zone Management Act (16 USC Section 1451 _et_ _seq_.)
Within designated coastal barrier	Prohibits any new Federal expenditure within the Coastal Barrier Resource System	Activity within the Coastal Barrier Resource System	Coastal Barrier Resources Act (16 USC 3501 _et_ _seq_.)

requirements for each alternative will be identified during the detailed evaluation of each alternative (Phase III). Table 5-6 identifies action specific requirements established under the Resource Conservation Recovery Act and the Clean Water Act.

State of Alaska action-specific ARARs are presented in Appendix Q.

5.1.4 Proposed State ARARs

The State of Alaska has proposed additional chemical, location, and action-specific ARARs. The proposed soil and groundwater cleanup standard discussion draft dated December 2, 1988, is included Appendix Q. The proposed groundwater cleanup standards and contaminated water discharged to groundwater standards due to contamination from petroleum products are listed below:

- Volatile Aromatics

Benzene	5 ug/L
Ethylbenzene	700 ug/L
Toluene	2000 ug/L
Xylenes	440 ug/L

- Non-aromatics
  Taste and odor

These proposed regulations will be used to evaluate remedial alternatives.

5.1.5 Anchorage Regional Landfill Contaminated Soil & Spill Residue Disposal Policy

The Municipality of Anchorage Solid Waste Services Contaminated Soil & Spill Residue Disposal Policy is included in Appendix Q with other

TABLE 5-6. SELECTED ACTION-SPECIFIC POTENTIALLY APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Standard, Requirement Criteria, or Limitation	Citation	Description	Comment
Federal			
Solid Waste Disposal Act (SWDA) as amended by the Resource Conservation and Recovery Act (RCRA)	42 USC Sect. 6901-6987		
Criteria for Classification of Solid Waste Disposal Facilities and Practices	40 CFR Part 257	Establishes criteria for use in determining which solid waste disposal facilities and practices pose a reasonable probability of adverse effects on health, and thereby constitute prohibited open dumps.	If an alternative developed would involve the land disposal of solid waste, this part would be applicable.
Hazardous Waste Management Systems General	40 CFR Part 260	Establishes procedure and criteria for modification or revocation of any provision in 40 CFR Parts 260-265.	May be applicable if a substance at the site was to be excluded from the list of hazardous wastes.
Identification and Listing of Hazardous Wastes	40 CFR Part 261	Defines those solid wastes which are subject to regulation as hazardous wastes under 40 CFR Parts 262-265 and Parts 124, 270, and 271.	Identifies those wastes considered to be hazardous wastes at the site. Any wastes considered as hazardous would be required to be handled as such.
Standards Applicable to Generators of Hazardous Waste	40 CFR Part 262	Establishes standards for generators of hazardous waste.	If an alternative developed would involve offsite disposal or treatment of hazardous materials, these standards would be applicable.
Standards Applicable to Transporters of Hazardous Waste	40 CFR Part 263	Establishes standards which apply to persons transporting hazardous waste within the U.S. if the transportation requires a manifest under 40 CFR Part 262.	If an alternative developed would involve offsite transportation of hazardous materials, these standards would be applicable.
Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities	40 CFR part 264	Establishes minimum national standards which define the acceptable management of hazardous waste for owners and operators of facilities which treat, store, or dispose hazardous waste.	Subparts B through O may be applicable or relevant and appropriate to onsite and offsite remedial actions.
Interim Standards for Owners and Operators of Hazardous Waste Treatment Storage, and Disposal Facilities	40 CFR Part 265	Establishes minimum national standards that define the acceptable management of hazardous waste during the period of interim status and until certification of final closure or if the facility is subject to post-closure requirements, until post-closure responsibilities are fulfilled.	Remedies should be consistent with the more stringent Part 264 standards as these represent the ultimate RCRA compliance standards and are consistent with CERCLA's goal of long-term protection of public health and welfare and the environment.

TABLE 5-6 (Continued). SELECTED ACTION-SPECIFIC POTENTIALLY APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Standard, Requirement Criteria, or Limitation	Citation	Description	Comment
Standards for the Management of Specific Hazardous Wastes and Specific Types of Hazardous Waste Management Facilities	40 CFR Part 266	Establishes requirements which apply to recyclable materials that are reclaimed to recover economically significant amounts of precious metals, including gold and silver.	Does not establish additional cleanup requirements.
Interim Standards for Owners and Operators of New Hazardous Waste Land Disposal Facilities	40 CFR Part 267	Establishes minimum national standards that define acceptable management of hazardous waste for new landfill disposal facilities.	Remedies should be consistent with the more stringent Part 264 standards as these represent the ultimate RCRA compliance standards and are consistent with CERCLA's goal of long-term protection of public health and welfare and the environment.
Land Disposal	40 CRF Part 268	Established a timetable for restriction of burial of wastes and other hazardous materials.	If an alternative developed would involve burial or prohibited material, this part would be applicable.
Hazardous Waste Permit Program	40 CFR Part 270	Establishes provisions covering basic EPA permitting requirements.	Substantive requirements are addressed in 40 CFR Part 264.
Underground Storage Tanks	40 CFR Part 280	Establishes regulations related to underground storage tanks.	Would be applicable if an alternative would involve use or remediation of underground storage tanks.
Occupational Safety and Health Act	29 USC Sect.	Regulates worker health and safety.	Under 40 CFR Sect 300.38, requirements of the Act apply to all response activities under the NCP.
Safe Drinking Water Act	42 USC Sect. 300(f)		
Standards for Owners and Operators of Public Water Supply System	40 CFR 141	Provides treatment (water quality) requirements for public water supply	MCLs may be relevant and appropriate to the establishment of cleanup goals for groundwater contamination.
Underground Injection Control Regulations	40 CFR Parts 144-147	Provides for protection of underground sources of drinking water.	If an alternative developed would involve underground injection, this part is applicable.

TABLE 5-6 (Continued). SELECTED ACTION-SPECIFIC POTENTIALLY APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Standard, Requirement Criteria, or Limitation	Citation	Description	Comment
Clean Water Act	33 USC Sect. 1251-1376		
National Pollutant Discharge Elimination System	40 CFR Parts 122, 125	Requires permits for the discharge of pollutants from any point source into waters of the United States.	A permit is required for an alternative developed which discharges into a creek, other surface water, or the storm sewer.
National Pretreatment Standards	40 CFR Part 403	Sets standards to control pollutants which pass through or interfere with treatment process in publicly owned treatment works which may contaminate sewage sludge.	If an alternative developed involved discharge to publicly owned treatment works these standards would be applicable.
Toxic Pollutant Effluent Standards	40 CFR Part 129	Establishes effluent standards or prohibitions for certain toxic pollutants: aldrin/dieldrin, DDT, endrin, toxaphene, benzidine, PCBs.	These contaminants were not detected in the groundwater at the site.
Marine Protection Research and Sanctuaries Act	13 USC Sect. 1401-1445	Regulates ocean dumping.	No ocean dumping will occur.
Clean Air Act	42 USC Sect. 7401-7642		
National Ambient Air Quality Standards	40 CFR 50 40 CFR 53 40 CFR 61	Treatment technology standard for emissions to air	If an alternative developed would involve emissions governed by these standards, then the requirements are applicable.
Hazardous Materials Transportation Act	40 USC Sect. 1801-1813		
Hazardous Materials Transportation Regulations	49 CFR Parts 107, 171-177	Regulates transportation of hazardous materials.	If an alternative developed would involve transportation of hazardous materials, these requirements are applicable.

TABLE 5-6 (Continued). SELECTED ACTION-SPECIFIC POTENTIALLY APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Standard, Requirement Criteria, or Limitation	Citation	Description	Comment
State			
Alaska Administrative Code (AAC)			
Wastewater Disposal	18 AAC 72	Established requirements for discharging nondomestic wastewater to sewers and waters of Alaska sludge disposal, and design and operation of treatment works.	Any alternative which treats nondomestic wastewater and/or discharges it into a sewer, POTW, or receiving water will have to meet the requirements of this regulation.
Oil Pollution Regulations	18 AAC 75	Establishes criteria for cleanup and disposal of hazardous waste.	Cleanup activities may be regulated by these standards.

State of Alaska ARARs. The Policy indicates that no soil will be accepted that:

- Exhibits hazardous waste characteristics for ignitability, corrosivity, reactivity or toxicity or contains listed hazardous waste as defined by the EPA or ADEC.

- Contains free liquids as defined by the EPA Paint Filter Test.

- Contains TPH at concentrations greater than 1000 ppm.

- Contains BETX at concentrations greater than 100 ppm.

Information requirements which must be submitted to the Solid Waste Services Department to determine acceptability of the soil at the landfill are also presented in Appendix Q.

5.2 PRELIMINARY ALTERNATIVE RESPONSE ACTIONS (FS PHASE I)

During this phase of the FS, preliminary alternative response actions are developed by combining technologies into alternatives that address the contaminants identified at each site. This process is completed in this section using a 5 step process as follows:

1. Development of remedial action objectives for remediating soil and/or groundwater contamination at each of the 7 sites.

2. Development of general response actions which address the remedial action objectives and the most probable site conditions.

3. Identification of the probable site conditions and those reasonable deviations that may affect implementation of remedial measures.

4. Identification and screening of remedial technologies and process options on the basis of their technical implementability, effectiveness, and relative cost.

5. Development of alternatives which meet the remedial action objectives by combining technologies which have passed screening.

5.2.1 Remedial Action Objectives

The primary purpose of the FS is to identify, screen, analyze, and compare remedial alternatives that achieve protection of human health and the environment. In order to accurately compare and analyze different alternatives, specific objectives or goals for remediation must first be established.

The specific goals for remedial action at Sites D-16, IS-1, SP-5/5A, SP-7/10 and SP-15 are as follows:

- Prevent ingestion of and contact with groundwater or soil having concentration levels in excess of target cleanup levels. Target cleanup levels are based on ARARs and are defined later in this section.

- Prevent further migration of soil and groundwater contaminants to other media or receptors.

- Improve soil and groundwater quality to target cleanup levels.

The media of concern at Site D-16, is soil because only soil samples were collected at the site; although, it is possible that groundwater contamination has also occurred. Further investigation is required to determine the effects of soil contamination on groundwater quality at Site D-16. The media of concern at Sites IS-1, SP-5/5A, SP-7/10 and SP-15 is groundwater. Only low levels of contaminants were detected in soils at these sites, generally below the cleanup levels suggested by the interim ADEC guidelines. Where cleanup guidelines were exceeded, contamination was the saturated zone. Therefore, groundwater extraction will effectively treat the soil contamination.

The potential exposure pathways at the FS sites include consumption of, and contact with, contaminated groundwater and/or soil. In addition, the potential may exist for offsite transport of contaminants through migration of groundwater to receptor wells, surface waters and by leaching of soil contaminants into underlying groundwater. Most of the potentially affected receptor wells are not screened in the shallow groundwater system and should not be impacted by the contaminants unless well construction techniques allowed cross-contamination between the aquifers or other hydraulic connections exist between the shallow and deep groundwater systems. Base well number 1 (BW-1), which is located at Building 23-990, is an exception since it is screened at a depth of only 16 feet into the shallow aquifer.

The source of contamination at the FS sites designated for remedial action has been associated with the release of petroleum products into the environment. The released petroleum products common to each site are aviation gasoline and/or jet fuels. The hazardous contaminants of concern from these products are the volatile aromatic hydrocarbons benzene, ethylbenzene, toluene, and xylene (BETX). The BETX compounds have varying degrees of toxicity. Benzene is of most concern because it is known to cause cancer in humans. These compounds share the common characteristic of being both volatile to the atmosphere and soluble in water. Total petroleum hydrocarbon (TPH) from released

fuel products also represents a concern in soil and groundwater at each of the sites. However, TPH is less volatile, less soluble and has less risk associated with exposure.

Target cleanup levels for groundwater contaminated with petroleum products are based on ARARs discussed in Section 5.1. Table 5-7 lists the maximum concentration detected for each contaminant of concern along with the target cleanup level. Each of these target levels is equal to or more stringent than current state drinking water standards.

The proposed state regulations for cleanup of groundwater do not provide a quantitative value for TPH concentration. Therefore, cleanup goals will be based on Water Quality Standards.

There are currently no regulatory cleanup standards or action levels for soils required by the State of Alaska. However, there are interim soil cleanup guidelines. In addition, the requirements for soil remediation are reviewed by ADEC on a site by site basis (personal communications with Colleen Berg and Jim Hayden, ADEC, 1989). For the purposes of this study, target cleanup levels for soils at Site D-16 will be set at 100 ppm TPH. Proposed soil cleanup levels guidelines for the State of Alaska are based on an assessment matrix developed by the State of California which is included in Appendix Q. Maximum allowable TPH levels are either 1000 ppm, 100 ppm, or 10 ppm depending on depth to groundwater, soil characteristics, hydraulic conductivity, precipitation and migratory routes. Based on the features at Site D-16 it appears that the maximum allowable TPH level will be 100 ppm. However, the assessment matrix is only to be used as a tool. ADEC involvement is necessary to develop actual cleanup levels. Site D-16

TABLE 5-7. TARGET CLEANUP LEVELS FOR GROUNDWATER

Contaminant	Maximum Detected Contamination (ug/L) IS-1	SP-5/5A	SP-7/10	SP-15	Target Cleanup Levels[1] (ug/L)
TPH	Pure Product	Pure Product	Pure Product	3,000	(2)
Benzene	35	21,000	3,200	170	5
Toluene	460	26,000	7,100	300	2,000
Ethylbenzene	250	2,700	1,300	100	700
Xylene	1,050	10,900	5,100	400	440

(1) Based on ADEC Proposed Soil and Groundwater Cleanup Standards Discussion Draft: December 2, 1988.

(2) Use Water Quality Criteria.

was found to contain high levels of TPH contamination in near surface (up to 8160 mg/kg) and subsoil (up to 1110 mg/kg) samples and therefore the determination was made, independent of ADEC review, to include the site in the feasibility study for soil remediation. Sites IS-1, SP-5/5A, SP-7/10, and SP-15, on the other hand, showed no evidence of significant BETX contamination in unsaturated soils and therefore only groundwater remediation will be evaluated for these sites. Further analysis will be required to determine whether or not more pollutants, such as BETX, exist in both water and soil samples collected at Site D-16.

5.2.2 General Response Actions

In order to address the remedial action objectives for site remediation, general response actions have been developed for each environmental medium.

A summary of general response actions for groundwater and soil is given in Table 5-8. The table also provides a brief description of each response action.

5.2.3 Probable Site Conditions and Reasonable Deviations

The field investigation program did not completely characterize the 7 sites evaluated in the FS. The RI indicated that further investigation is needed at each site to better delineate the extent of contamination. This FS is being undertaken with an understanding of the existing data gaps in order to prevent further migration of soil and groundwater contaminants. To complete this FS report, it was necessary to identify probable site conditions which exist at each site and any reasonable departures from those conditions which would affect the implementation of a remedial action.

TABLE 5-8. SUMMARY OF GENERAL RESPONSE ACTIONS (Sites D-16, IS-1, SP-5/5A, SP-7/10, SP-15)

General Response Action	Description
Groundwater:	
No Action	No remedial action is conducted. Used as a baseline by which to compare other alternatives.
Institutional Controls	Technologies or restrictions which regulate public contact with the contaminants.
Collection	Technologies which collect and remove the contaminated groundwater.
Containment	Physical or hydraulic barriers which prevent or restrict the continued migration of pollutants offsite.
Onsite Treatment/ Discharge	Technologies which treat the groundwater to reduce or eliminate hazardous characteristics. Treated effluent is subsequently discharged to the environment.
Offsite Treatment/ Disposal	Groundwater is treated at an offsite facility. Effluent and secondary wastes are discharged or disposed of according to applicable regulations.
Soils:	
No Action	Same as described for groundwater.
Institutional Controls	Same as described for groundwater.
Containment	Physical barriers to prevent further migration of contaminants offsite or into underlying groundwater.
Excavation/Offsite Disposal	Soil is excavated and disposed of according to applicable regulations.

TABLE 5-8 (Continued). SUMMARY OF GENERAL RESPONSE ACTIONS
(Sites D-16, IS-1, SP-5/5A, SP-7/10, SP-15)

General Response Action	Description
Excavation/Treatment and Disposal	Soil is excavated and transported to an approved facility for treatment to reduce or eliminate hazardous characteristics.
In-Situ Treatment	Soils are treated in place to reduce or eliminate hazardous characteristics.

The information obtained from the field investigation program, which is summarized in Section IV, was used to develop a conceptual model of current conditions at each site. The model provides the most informed assessment of the site by defining the set of conditions likely to exist at the site (i.e. the probable site conditions). The conceptual model also identifies reasonable deviations from the probable site conditions, thereby acknowledging the data gaps and uncertainties.

The probable site conditions and reasonable deviations are broken into seven site characteristics:

1. Nature of Contamination.
2. Extent of Contamination.
3. Site Geology.
4. Site Hydrogeology.
5. Sources of Contamination.
6. Site Groundwater Uses.
7. Site Groundwater Quality.

Tables 5-9 through 5-13 provide summaries of the probable site conditions and the reasonable deviations which might effect implementation of remedial measures at each site. Figures 5-1 through 5-5 illustrate the assumed limits of contamination and direction of groundwater flow for each site as discussed in Tables 5-9 through 5-13. The assumed limits of contamination as outlined on the figures represent the area where the concentration potentially exceeds target cleanup levels. The areas were determined on the basis of groundwater and soil contaminant concentrations detected during the field investigation program (RI).

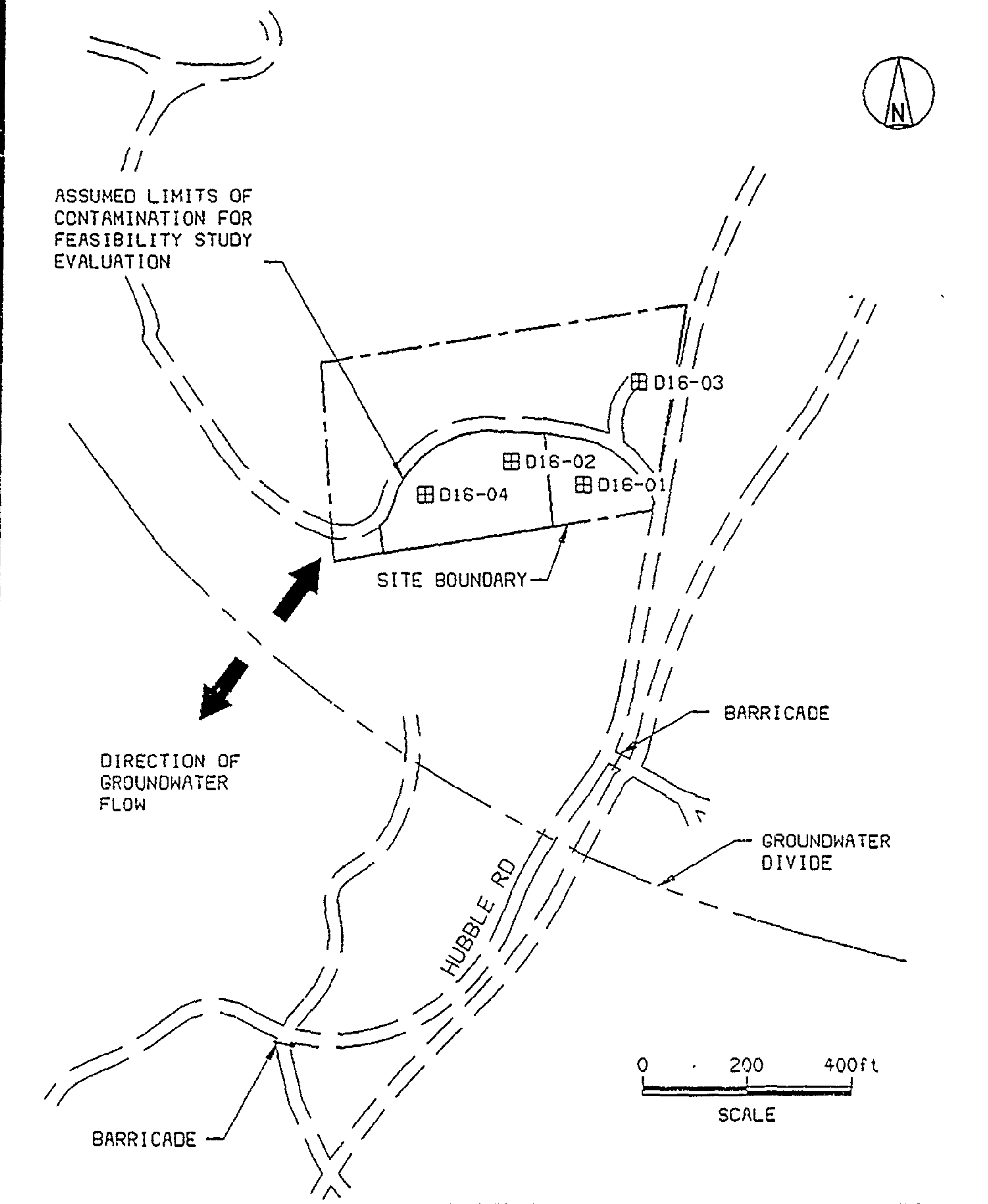
A special comment is made at this point in regard to using soil remediation to expedite or assist groundwater cleanup. In general, groundwater remedial actions cannot be evaluated without considering

TABLE 5-9. PROBABLE SITE CONDITIONS AND REASONABLE DEVIATIONS FOR SITE D-16

SITE CHARACTERISTICS	PROBABLE SITE CONDITIONS	REASONABLE DEVIATIONS
1. Nature of Contamination	Total petroleum hydrocarbon (TPH) contamination is apparent in the shallow (0 to 5 feet deep) soil system. Soil samples were only analyzed for TPH, lead, and total solids.	Soil samples were not analyzed for VOCs which may be present. Contaminant levels may be higher than those identified in the RI.
	Groundwater samples were not taken during the RI.	Groundwater may or may not be contaminated at the site.
2. Extent of Contamination	The assumed extent of contamination based on the results of the RI is illustrated on Figure 5-1. No contamination was detected in soil samples taken from D16-03 north of the access road, or from D16-01 on the eastern portion of the site; therefore, the assumed areal extent of contamination is as follows: North - extends to the access road. South - extends to the southern site boundary. East - extends to a line midway between D16-01 and D16-02. West - extends to the access road.	Contamination may extend further, in all directions, than currently assumed. No monitoring wells were installed or samples collected to determine if contamination has reached the groundwater.
	Soil samples were taken to a depth of five feet. TPH contamination increased with depth in bore-D16-04 from 380 mg/kg at the surface to 1110 mg/kg at a depth of five feet and decreased in depth in D16-02 from 8160 mg/kg at the surface to 410 mg/kg at a depth of five feet. It is therefore assumed that the average depth of contamination is greater than five feet. An average depth of contamination of six feet has been assumed.	Depth of contamination may vary from only surface contamination (0 to 1 foot deep) at some locations to depths greater than six feet at other locations.
	Based on the areal extent of contamination as described above, the total area of contamination is assumed to be 1.5 acres.	Total area may vary from one to three acres.
	Total volume of contaminated soil is assumed to be 15,000 CY.	Total volume of contaminated soil may vary by an order-of-magnitude due to deviations in areal extent and depth of contamination.
3. Site Geology	Stratigraphic units identified during the RI are continuous over the area surrounding the site.	Borings were completed to five feet, deposits at greater depths may include large cobbles, which may impact excavation costs.

TABLE 5-9 (Continued). PROBABLE SITE CONDITIONS AND REASONABLE DEVIATIONS FOR SITE D-16

SITE CHARACTERISTICS	PROBABLE SITE CONDITIONS	REASONABLE DEVIATIONS
4. Site Hydrogeology	Distance to water table was not directly measured at the site but was assumed to be 10 to 50 feet deep based on regional information.	The assumed distance to the water table is quite variable.
	Direction of groundwater flow at Site D-16 is to the northeast as indicated in Figure 5-1.	The location of the groundwater divide may shift to the northeast such that the direction groundwater flow at Site D-16 may be to the southwest rather than northeast.
	Hydraulic conductivities are not known.	
5. Potential Sources of Contamination	Past petroleums, oils, and lubricants (POL) sludge disposal practices at the site are the source of TPH contamination.	Disposal of other types of wastes may result in additional sources of contamination.
6. Site Groundwater Use	Shallow groundwater is not used as a source of drinking water near the site.	No reasonable deviations.
7. Site Groundwater Quality	Unknown.	No reasonable deviations.



LEGEND

⊞ D16-01 STAGE 3 BOREHOLE

ASSUMED LIMITS
OF CONTAMINATION
SITE D-16

IRP Stage 3 RI/FS
Elmendorf AFB, AK

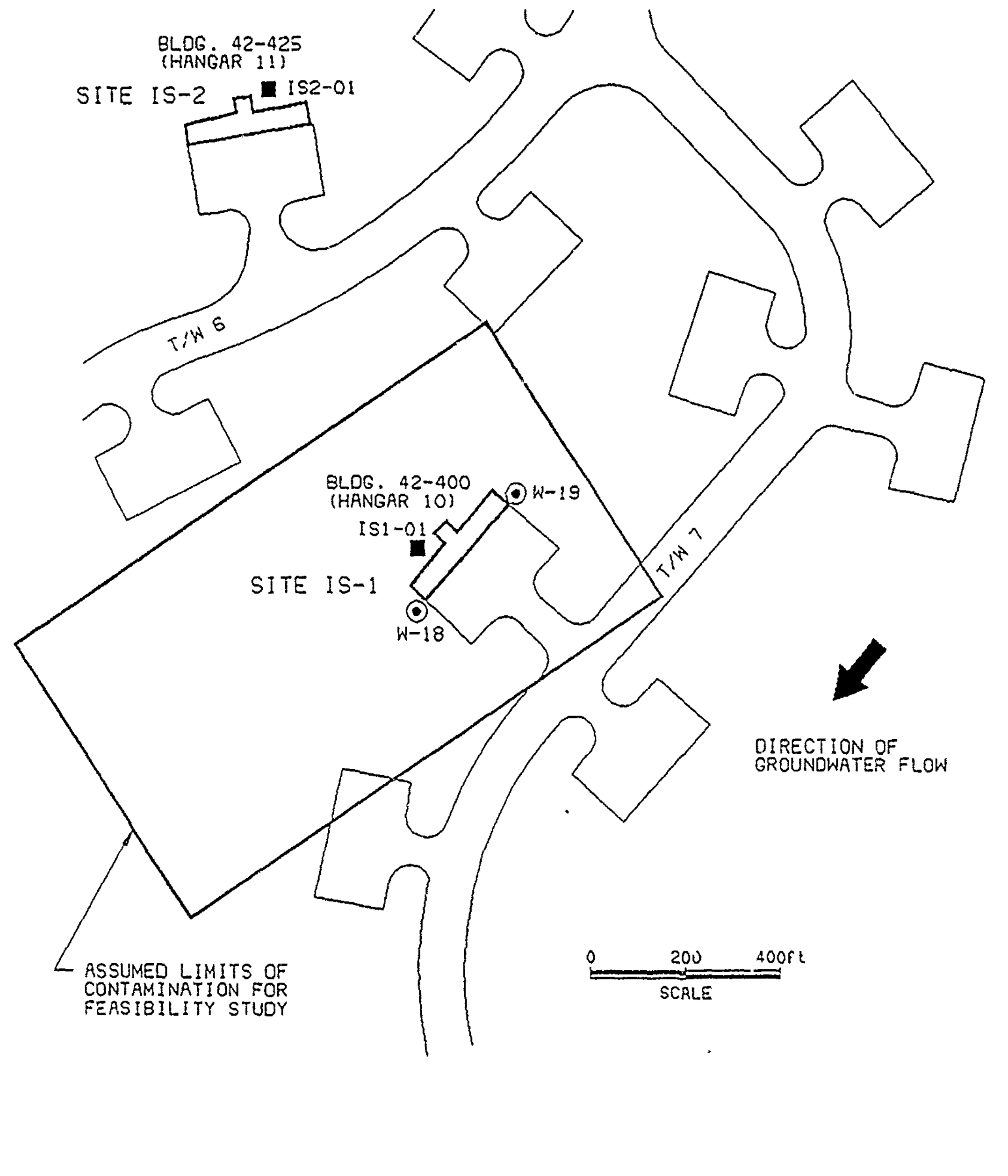
Figure 5-1

TABLE 5-10. PROBABLE SITE CONDITIONS AND REASONABLE DEVIATIONS FOR SITE IS-1

SITE CHARACTERISTICS	PROBABLE SITE CONDITIONS	REASONABLE DEVIATIONS
1. Nature of Contamination	TPH; benzene, ethylbenzene, toluene, xylene (BETX); and other volatile organic compounds (VOCs) were detected at the site. For purposes of calculating maximum TPH loading on various treatment alternatives, the average solubility of JP-4 in water at 8 C will be used. For BETX loading, the maximum observed concentrations will be used.	The vertical distribution of VOCs in groundwater are unknown. In general, fuel contamination will be higher toward the surface of the groundwater table. Some samples showed higher TPH values than would be expected based on the average solubility of jet fuels, indicating that samples were taken close to the surface and that pure floating product may have been mixed in.
2. Extent of Contamination	The assumed extent of contamination based on the RI is illustrated on Figure 5-2. The assumed areal extent of contamination is as follows: Upgradient (NE) Boundary - extends to the northeast limits of Hangar 10 (where the spills have occurred). Downgradient (SW) Boundary - extends in the direction of groundwater flow to a point just upgradient of Site IS-4. SE and NE Boundaries - extend in the direction of groundwater flow, are separated by 600 feet and contain Hangar 10. Based on the areal extent of contamination, the total area of contamination is assumed to be 16.5 acres. Total volume of contaminated water which may require treatment is assumed to be 36 million cubic feet based on the total area of contamination, site hydrogeology, and assuming that 2.5 volumes of the contaminated groundwater will be removed.	Contamination may extend further upgradient or downgradient than currently assumed or the plume may not extend as far downgradient as currently assumed. This would impact the areal extent of contamination. The total volume of contaminated water which may require treatment may vary from 19 million cubic feet to 58 million cubic feet by varying the porosity of the formation and the number of volumes of the contaminated groundwater which will be removed. Differences in the areal extent of contamination and thickness of the aquifer will also impact the assumed volume of contamination.
3. Site Geology	Stratigraphic unit identified during the RI are continuous over the area surrounding the site.	No reasonable deviations.
4. Site Hydrogeology	Depth to groundwater is 30 feet. Hydraulic conductivities are not known.	Depth to groundwater may vary by several feet.

TABLE 5-10 (Continued). PROBABLE SITE CONDITIONS AND REASONABLE DEVIATIONS FOR SITE IS-1

SITE CHARACTERISTICS	PROBABLE SITE CONDITIONS	REASONABLE DEVIATIONS
4. Site Hydrogeology (Con't)	Direction of groundwater flow as illustrated on Figure 5-2 is to the Southwest.	No reasonable deviations.
	The shallow groundwater is separated from lower groundwater systems by the BCF.	Hydraulic connections may exist between the shallow and deep systems.
	Porosity is assumed to be 0.375.	Porosity may vary from 0.25 to 0.5.
	Based on the pump test the aquifer is assumed to be 54 feet thick.	Aquifer thickness may be quite variable.
	The pump test was completed at a location with geologic conditions similar to Sites IS-1. The estimated radius of influence for extraction wells is 700 feet at 49 gpm and is based on the average transmissivity and storativity of the pump aquifer observed during the single pump test.	Actual radius of influence may vary up or down depending on actual site hydrogeologic conditions and pumping rates.
5. Potential Sources of Contamination	Fuel spills in Hangar 10 are the source of TPH, BETX, and some VOC contamination at the site.	Other spills or the disposal of other material to the dry well at Site IS-1 may result in additional sources of contamination (e.g., 1,1,1-trichloroethane and 1,2-dichloroethane were also detected but are not common components of fuel).
6. Site Groundwater Use	Shallow groundwater is not used as a source of drinking water. In general, base drinking water wells downgradient from FS sites are confined to the deeper artesian aquifer (>160 feet). However, base well number 1 at Building 23-990 draws water from the shallow aquifer at 16 feet but it should not be impacted by Site IS-1.	No reasonable deviations.
7. Site Groundwater Quality	Groundwater contains BETX compounds and other volatile organics. Dissolved metals concentrations are similar to background levels.	No reasonable deviations.



LEGEND

■ IS1-01 MONITORING WELL LOCATION STAGE 3

⊙ W-18 MONITORING WELL LOCATION PHASE II, STAGE 2

T/W TAXIWAY

ASSUMED LIMITS
OF CONTAMINATION
SITE IS-1

IRP Stage 3 RI/FS
Elmendorf AFB, AK

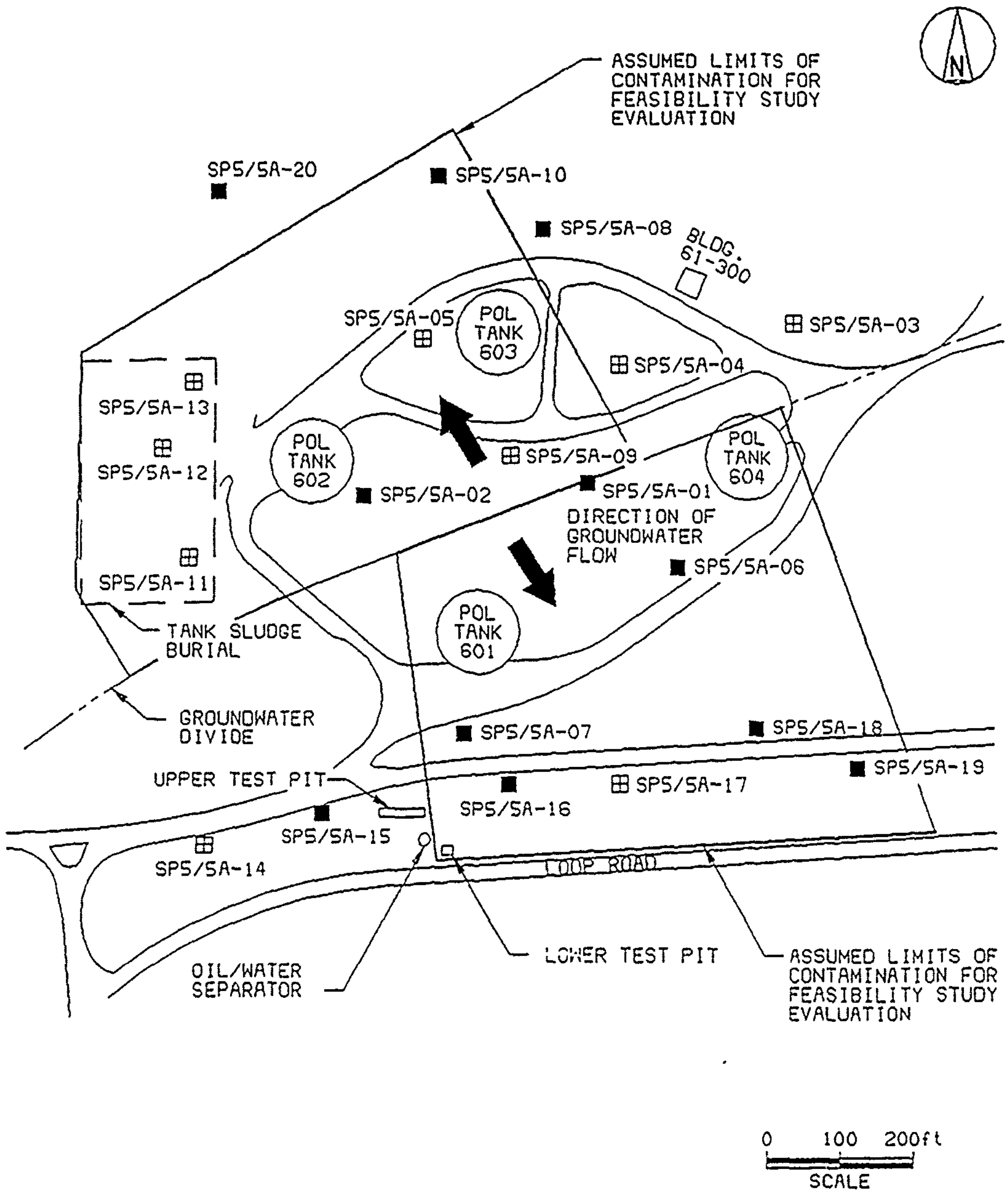
Figure
5-2

TABLE 5-11. PROBABLE SITE CONDITIONS AND REASONABLE DEVIATIONS FOR SITE SP-5/5A

SITE CHARACTERISTICS	PROBABLE SITE CONDITIONS	REASONABLE DEVIATIONS
1. Nature of Contamination	BETX, TPH, methylene chloride, and ethanol were detected in both water and soil samples taken at the site. Pure product was observed.	The vertical distribution of VOCs in groundwater are unknown. In general, fuel contamination will be higher toward the surface of the groundwater table. Some samples showed higher TPH values than would be expected based on the average solubility of jet fuels. The seep area at the site showed evidence of pure product mixed with groundwater.
	For purposes of calculating maximum TPH loading on various treatment alternatives, the average solubility of JP-4 in water at 8 C will be used. For BETX loading the maximum observed concentrations will be used.	
2. Extent of Contamination	The assumed extent of contamination based on results of the RI is illustrated on Figure 5-3.	Contamination may have migrated beyond the monitoring wells or boreholes.
	The boundaries were developed to include wells or borings where contamination was detected including wells SP5/5A-01, 06, 07, 10, 16, and 19 and boreholes SP5/5A-12 and 17.	The areal extent of contamination may be vary.
	Based on the areal extent of contamination, the total area of contamination is assumed to be 15 acres.	
	The total volume of contaminated water which may require treatment cannot be determined until the source of contamination is known.	
3. Site Geology	Glacial till consisting mainly of discontinuous poorly-sorted, brown silty gravel and gravelly silts with minor discontinuous layers of well-sorted sands and gravels overlying the BCF.	No reasonable deviations.
4. Site Hydrogeology	Depth to groundwater is at the ground surface near Loop Road, where seeps have been observed, to approximately 35 feet deep near the center of the site.	The distance to the groundwater table is already quite variable.
	Hydraulic conductivity at the site varies from 0.053 feet/day to 1.8 feet/day.	The actual values for hydraulic conductivity may vary because several boreholes at the site did not yield sufficient amounts of water to merit completion as monitoring wells and because the use of slug test methodology at well 8 was not possible because the water level response was too rapid.
	Direction of groundwater flow as illustrated in Figure 5-3 is to the southeast, south of the groundwater divide and to the northwest, north of the groundwater divide.	The location of the groundwater divide may shift, affecting the direction of groundwater flow.

TABLE 5-11 (Continued). PROBABLE SITE CONDITIONS AND REASONABLE DEVIATIONS FOR SITE SP-5/5A

SITE CHARACTERISTICS	PROBABLE SITE CONDITIONS	REASONABLE DEVIATIONS
5. Potential Sources of Contamination	Spills of aviation gasoline have occurred several times since the tanks were installed in the 1940's.	POL tanks and piping may be leaking. Unknown or unreported spills may have occurred.
6. Site Groundwater Use	Shallow groundwater is not used as a source of drinking water. In general, base drinking water wells downgradient from FS sites are confined to the deeper artesian aquifer (>160 feet). Base well number 1 at Building 23-990 draws water from the shallow aquifer at 16 feet, but it should not be impacted by Site SP-5/5A.	No reasonable deviations.
7. Site Groundwater Quality	Volatile organics and TPH are present in groundwater.	No reasonable deviations.



LEGEND

⊞	SP5/5A-01	STAGE 3 BOREHOLE
■	SP5/5A-03	MONITORING WELL LOCATION STAGE 3
	POL	PETROLEUM, OILS, AND LUBRICANTS

ASSUMED LIMITS OF CONTAMINATION SITE SP-5/5A

IRP Stage 3 RI/FS
Elmendorf AFB, AK

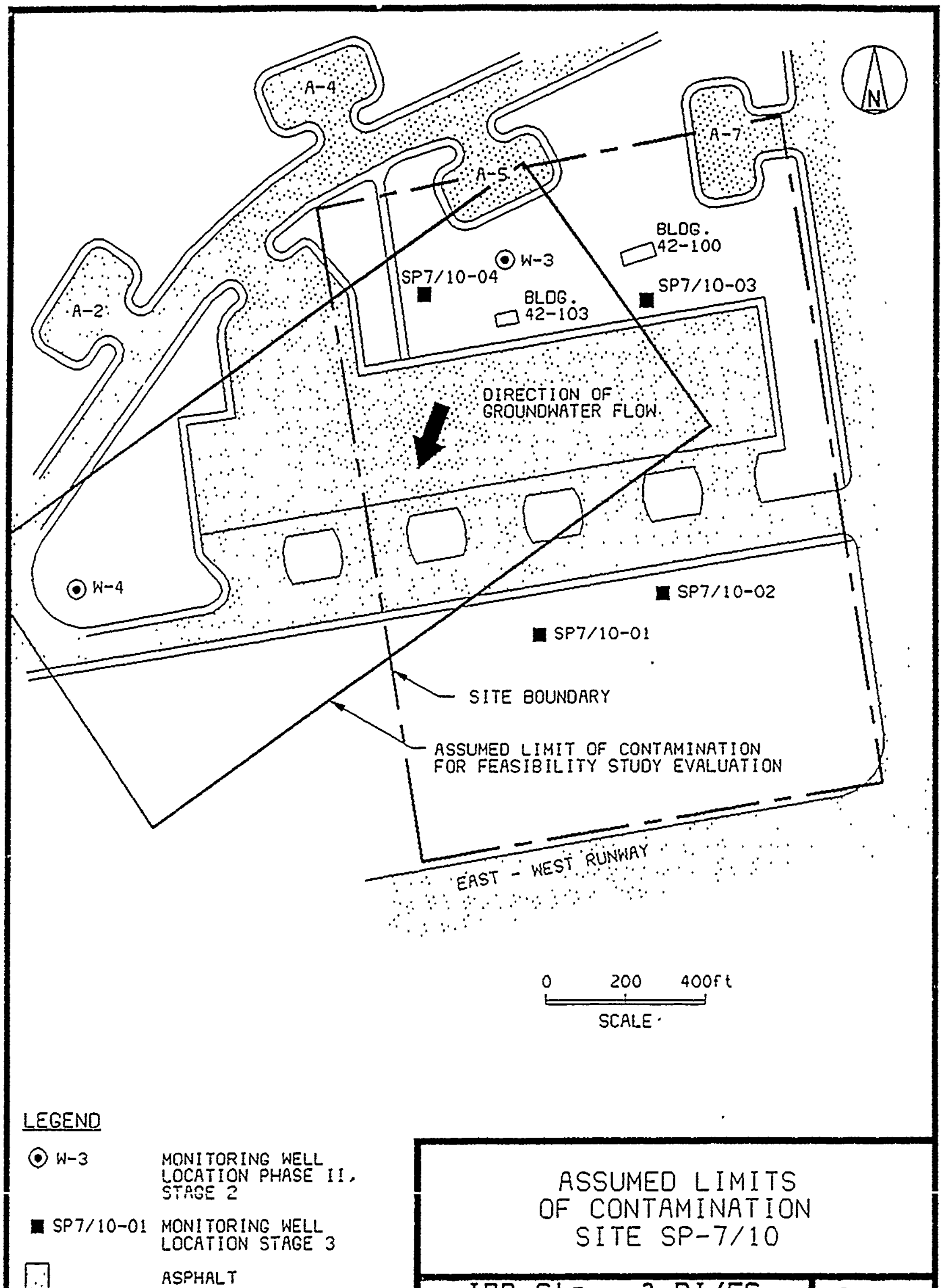
Figure 5-3

TABLE 5-12. PROBABLE SITE CONDITIONS AND REASONABLE DEVIATIONS FOR SITE SP-7/10

SITE CHARACTERISTICS	PROBABLE SITE CONDITIONS	REASONABLE DEVIATIONS
1. Nature of Contamination	The only contaminants detected in the groundwater at Site SP-7/10 were BETX and TPH. TPH and xylenes were also detected in soil samples taken from the site. For purposes of calculating maximum TPH loading on various treatment alternatives, the average solubility of JP-4 in water at 8 C will be used. For BETX loading, the maximum observed concentrations will be used.	The vertical distribution of VOCs in groundwater are unknown. In general, fuel contamination will be higher toward the surface of the groundwater table. Some samples showed higher TPH values than would be expected based on the average solubility of jet fuels, indicating that samples were taken close to the surface and that pure floating product may have been mixed in.
2. Extent of Contamination	The assumed extent of contamination based on the results of the RI is illustrated on Figure 5-4. The highest levels of contamination were detected in wells SP7/10-04 and W-3. Lower levels of contamination were detected in wells SP7/10-01 and W-4. No contaminants were detected in wells SP7/10-02 and 03. Therefore, the assumed areal extent of contamination is as follows: Upgradient (NE Boundary) - extends to a line just downgradient of well SP7/10-03. Downgradient (SW Boundary) - extends to a line just downgradient of well W-4. NW Boundary - extends to a line abovegradient of probable contaminant migration based on groundwater flow. SE Boundary - extends to a line just upgradient of well SP7/10-01 which was contaminated with low levels of xylene (0.24 ug/L). The target cleanup level for xylene is 440 ug/L. Based on the areal extent of contamination, the total area of contamination is assumed to be 25 acres. Total volume of contaminated water which may require treatment is assumed to be 55 million cubic feet, based on the total area of contamination, site hydrogeology, and assuming that 2.5 volumes of the contaminated groundwater will be removed.	The contaminants may have migrated further downgradient towards the East-West runway which would impact areal extent of contamination. The total volume of contaminated water which may require treatment may vary from 29 million cubic feet to 87 million cubic feet by varying the porosity of the formation and the number of volumes of the contaminated groundwater which will be removed. Differences in the areal extent of contamination and thickness of the aquifer will also impact the assumed volume of contamination.
3. Site Geology	Stratigraphic units identified in the RI are continuous over the area surrounding the site.	No reasonable deviations.

TABLE 5-12 (continued). PROBABLE SITE CONDITIONS AND REASONABLE DEVIATIONS FOR SITE SP-7/10

SITE CHARACTERISTICS	PROBABLE SITE CONDITIONS	REASONABLE DEVIATIONS
4. Site Hydrogeology	Depth to groundwater is 18 feet.	Depth to groundwater may vary from 12 feet to 22 feet.
	Hydraulic conductivity values are not known.	
	Based on the pump test the aquifer is assumed to be 54 feet thick.	Aquifer thickness may be quite variable.
	The pump test was completed at a location with geologic conditions similar to Site SP-7/10. The estimated radius of influence for extraction wells is 700 feet at 40 gpm and is based on the average transmissivity and storativity of the aquifer observed during the single pump test.	Actual radius of influence may vary up or down depending on actual site hydrogeologic conditions.
	Direction of regional groundwater flow is to the southwest. The Elmendorf Moraine which is northwest of the site causes groundwater to flow to the southwest.	No reasonable deviations.
	The shallow groundwater is separated from lower groundwater systems by the Bootlegger Cove Formation (BCF).	Hydraulic connections may exist between the shallow and deep groundwater systems.
	Porosity is assumed to be 0.375.	Porosity may vary from 0.25 to 0.5.
5. Potential Sources of Contamination	A 50,000 gallon (1964) and a 36,000 gallon (1980) JP-4 fuel spill occurred at Building 42-103 (Engineering-Science 1983). Little or no fuel was recovered from either spill.	Other unreported spills may have occurred.
6. Site Groundwater Use	Shallow groundwater is not used as a source of drinking water. In general, base drinking water wells downgradient from FS sites are confined to the deeper artesian aquifer (>160 feet). However, base well number 1 at building 23-990 draws water from the shallow aquifer at 16 feet but it should not be impacted by Site SP-7/10.	No reasonable deviations.
7. Site Groundwater Quality	Groundwater is contaminated by BETX and TPH.	No reasonable deviations.



ASSUMED LIMITS
OF CONTAMINATION
SITE SP-7/10

IRP Stage 3 RI/FS
Elmendorf AFB, AK

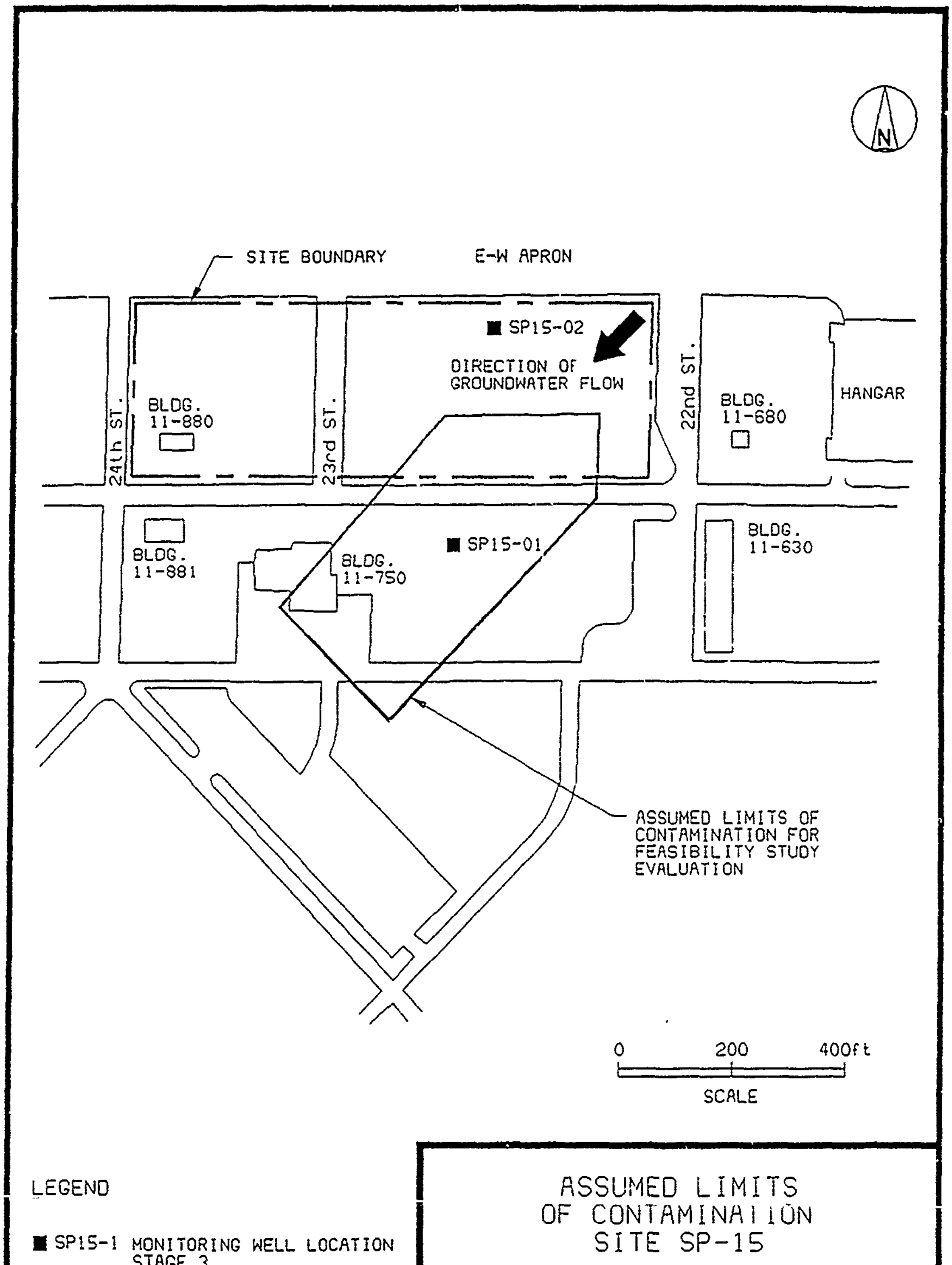
Figure
5-4

TABLE 5-13. PROBABLE SITE CONDITIONS AND REASONABLE DEVIATIONS FOR SITE SP-15

SITE CHARACTERISTICS	PROBABLE SITE CONDITIONS	REASONABLE DEVIATIONS
1. Nature of Contamination	Benzene was detected in a water sample taken from well SP15-01. TPH, toluene, ethylbenzene, and xylenes were detected in both soil and water samples collected from well SP15-01. For purposes of calculating maximum TPH loading on various treatment alternatives, the average solubility of JP-4 in water at 8 C will be used. For BETX loading, the maximum observed concentrations will be used.	The vertical distribution of VOCs in groundwater are unknown. In general, fuel contamination will be higher toward the surface of the groundwater table. Some samples showed higher TPH values than would be expected based on the average solubility of jet fuels, indicating that samples were taken close to the surface and that pure floating product may have been mixed in.
2. Extent of Contamination	The assumed extent of contamination based on the results of the RI is illustrated in Figure 5-5. The assumed areal extent of contamination is as follows: Upgradient (Northern Boundary) - extends to a line south of well SP15-02 where no contaminants were detected but north of the road where a 1000 gallon AVGAS spill occurred (Engineering-Science, 1983). Downgradient (Southwestern Boundary) - extends to a line perpendicular to groundwater flow southwest of well SP15-01. NW and SE Boundary - extends to a line 150 feet on either side of a line parallel with groundwater flow from the area where the spill probably occurred. Based on the areal extent of contamination, the total area of contamiantion is assumed to be 4 acres. Total volume of contaminated water which may require treatment is assumed to be 9 million cubic feet, based on the total area of contamination, site hydrogeology, and assuming that 2.5 volumes of the contaminated groundwater will be removed.	The contamination may be much further downgradient than identified on Figure 5-5 which will impact the areal extent of contamination. The total volume of contaminated water which may require treatment may vary from 8 million cubic feet to 14 million cubic feet by varying the porosity of the formation and the number of volumes of the contaminated groundwater which will be removed. Differences in the areal extent of contamination and thickness of the aquifer will also impact the assumed volume of contamination.
3. Site Geology	Stratigraphic units identified in the RI are continuous over the area surrounding the site.	No reasonable deviations.

TABLE 5-13 (Continued). PROBABLE SITE CONDITIONS AND REASONABLE DEVIATIONS FOR SITE SP-15

SITE CHARACTERISTICS	PROBABLE SITE CONDITIONS	REASONABLE DEVIATIONS
4. Site Hydrogeology	Depth to groundwater is 27 feet.	Depth to groundwater may vary from 25 feet to 30 feet.
	Hydraulic conductivities are unknown.	
	Direction of groundwater flow as illustrated on Figure 5-5 is to the southwest.	No reasonable deviations.
	The shallow groundwater is separated from lower groundwater systems by the BCF.	Hydraulic connections may exist between the shallow and deep groundwater systems.
	Porosity is assumed to be 0.375.	Porosity may vary from 0.25 to 0.3.
	Based on the pump test, the aquifer is assumed to be 54 feet thick.	Aquifer thickness may be quite variable.
	The pump test was completed at a location with geologic conditions similar to Site SP-15. The estimated radius of influence for extraction wells is 700 feet at 40 gpm and is based on the average transmissivity and storativity of the aquifer observed during the single pump test.	Actual radius of influence may vary up or down depending on actual site hydrogeologic conditions.
5. Potential Source of Contamination	A 1000 gallon AVGAS spill occurred north of O Street in 1961. Most of the spill was contained and collected.	Unreported spills may have occurred at the site.
6. Site Groundwater Use	Shallow groundwater is not used as a source of drinking water. In general, base drinking water wells downgradient from FS sites are confined to the deeper artesian aquifer (>160 feet). However, base well number 1 at Building 23-990 draws water from the shallow aquifer at 16 feet but it should not be impacted by Site SP-15.	No reasonable deviations.
7. Site Groundwater Quality	BETX and TPH are present in the groundwater.	No reasonable deviations.



ASSUMED LIMITS
OF CONTAMINATION
SITE SP-15

IRP Stage 3 RI/FS
Elmendorf AFB, AK

Figure 5-5

source control actions, because source control actions usually contribute to groundwater restoration. If the source of contamination is found in the unsaturated area lying above the groundwater table, soil remediation may be essential to groundwater cleanup since the potential for continued long term migration of contaminants from soils into groundwater exists. Should source contamination remain in the soil, it may require more extensive groundwater remedial actions, possibly resulting in higher remediation costs.

In light of these considerations, each site included in the FS for groundwater remediation was also evaluated in term of its potential for containing source contamination in the vadose zone. The evaluation was based primarily on soil samples analyzed by the laboratory and on results of the soil gas survey during the field investigation. The following is a summary of findings from the evaluation:

- Laboratory analyses of soil samples at individual sites confirmed only that contamination by BETX compounds exist in groundwater. The data did not provide evidence of source contamination in or originating from the vadose zone.

- Data from the soil gas survey showed evidence of relatively high concentrations of volatile hydrocarbon gases in the vadose zone for some areas which seems to contradict the laboratory findings. In some cases, the same location which showed little or no contamination by the laboratory method showed significant hydrocarbon concentrations with the soil gas method.

- The apparent discrepancy between the two sets of analyses may be fully or partially attributed to the soil gas method detecting hydrocarbons which have volatilized from a source of concentrated free floating product on the groundwater table beneath the soil area and not from the soil itself.

- o Most laboratory samples were taken at 2 depths only, with the deeper of the 2 at or below the groundwater table. Therefore, in some instances, a large area remains for potential soil source contamination between the 2 data points.

Two conclusions can be drawn from the above evaluation of soil data. First, there is currently no evidence to suggest that source contamination exists in the vadose zone at each of the sites (excluding D-16) that would contribute to substantial long term migration of contaminants into the groundwater. Second, the extent of soil testing to date is not sufficient to conclude, without question, that there are no remaining sources of released fuel product in the vadose zone. Further testing should be conducted to determine if any source locations exist, and, if so, the spatial extent of contamination and the potential long term effect it may have on groundwater cleanup should also be determined.

In the event that a substantial source of contamination is found in the vadose zone at a given site, technologies such as surface capping and soil vapor extraction (described in Section 5.2.6) are alternatives which should be reconsidered. Vapor extraction has shown favorable removal of BETX compounds from soils contaminated with fuel product. While vapor extraction is a viable approach to assisting groundwater cleanup by removing contaminants from the unsaturated zone, it is not by itself as effective for groundwater remediation as the pump and treat methods that will be evaluated.

5.2.4 Identification and Screening of Remedial Technologies and Process Options

Technologies and associated process options have been identified for each environmental media and general response action discussed in

Section 5.2.2. A range of potential remedial technologies for Sites D-16, IS-1, SP-5/5A, SP-7/10, and SP-15 are presented in Tables 5-14 and 5-15. The preliminary technologies and process options are screened with respect to technical implementability. The purpose of the screening is to eliminate those technologies and process options which are clearly inapplicable or infeasible. The waste characteristics and general conditions at each site have been considered in this screening analysis. Special consideration has been given to those technologies which result in the destruction or significant reduction of contaminant levels, while producing low volumes of secondary waste for subsequent disposal.

The results of the preliminary screening process for soil and groundwater contamination are summarized in Tables 5-14 and 5-15, respectively. Screening comments regarding the technical implementability of the technologies and process options have also been included in the tables.

5.2.5 Further Screening of Process Options

In this section, the process options associated with each technology are evaluated in greater detail and screened further in order to reduce the total number of alternatives to be carried into Phase II of the FS. One process option, if possible, is selected for each technology type, while maintaining a wide and flexible range of options. The criteria used in this screening are based on process effectiveness, implementability, and cost.

The effectiveness of each process option was evaluated based on the following:

- The potential effectiveness in obtaining and meeting remedial objectives.

TABLE 5-14. INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS (SOILS, SITE D-16)

SOIL GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	SCREENING COMMENTS	STATUS
No Action	None	Not Applicable	No Action	Required for consideration by NCP.	RETAINED
Institutional Control	Access Restriction	Fencing	Human access is restricted with chain-link fence.	Potentially applicable.	RETAINED
	Future Restrictions	Deed Restrictions	Deeds for property in area of potential contamination would include restrictions on wells.	Not applicable on AFB property.	Rejected
	Monitoring	Groundwater Monitoring	Ongoing monitoring of groundwater to determine if soil contamination is impacting groundwater quality.	Potentially applicable.	RETAINED
Containment	Cover/Cap	Clay & Soil	Compacted clay is covered with soil in areas of contamination to reduce contaminant leaching as a result of surface water infiltration.	Potentially applicable in conjunction with other technologies.	RETAINED
		Asphalt	Installation of asphaltic pavement over areas of contamination to reduce surface water infiltration.	Severe weather may reduce effectiveness due to cracking.	Rejected
		Concrete	Installation of a concrete slab over areas of contamination to reduce surface water infiltration.	Severe weather may reduce effectiveness due to cracking.	Rejected
		Multi-layer	Contaminated soil is covered with clay and synthetic membrane and then compacted soil to reduce surface water infiltration.	Potentially applicable in conjunction with other technologies.	RETAINED
	Vertical Barriers	Slurry Wall	Trench around areas of contamination is filled with a soil (or cement)/bentonite slurry to create a wall of low permeability.	Potentially applicable.	RETAINED
		Grout Curtain	Grout is pressure injected in a regular pattern of drilled holes around contaminated area to create a wall of low permeability.	Generally incapable of attaining low permeabilities in unconsolidated materials.	Rejected

TABLE 5-14 (Continued). INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS (SOILS, SITE D-16)

SOIL GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	SCREENING COMMENTS	STATUS
Containment (Con't)	Vertical Barriers (Con't)	Vibrating Beam	A vibrating force is used to advance beams into the ground followed by injection of slurry as the beam is withdrawn.	Not feasible because of layers of large material (cobbles) which would make installation difficult.	Rejected
	Horizontal Barriers	Grout Injection	Grout is pressure injected at depth through closely spaced drilled holes to create a low permeability barrier below the area of contamination.	Best suited for filling voids in rock. Not effective in unconsolidated material.	Rejected
		Block Displacement	Used in conjunction with vertical barriers. Injection of slurry in holes bored through contaminated area causes displacement of the contaminated block of earth.	Experimental technique, not yet tested and still being refined.	Rejected
Soil Removal/ Disposal	Excavation	Excavation	Physical removal of soil.	Potentially applicable.	RETAINED
	Onsite Disposal	Onsite RCRA Landfill	An onsite landfill is constructed that complies with RCRA provisions for the disposal of hazardous waste.	Potentially applicable.	RETAINED
	Offsite Disposal	Sanitary Landfill	Disposal of contaminated soil at a local sanitary landfill.	Local landfill accepts wastes containing less than 1000 ppm TPH.	RETAINED
		RCRA Landfill	Disposal of soil at a RCRA-permitted facility if soil is determined to be a hazardous waste.	No RCRA facilities are located in Alaska. Soil would have to be hauled out of state.	RETAINED
Soil Removal/ Treatment	Excavation	Excavation	Physical removal of soil.	Potentially applicable.	RETAINED
	Thermal	Rotary Kiln	Combustion of excavated soil occurs in a horizontally rotating cylinder designed for uniform heat transfer.	Potentially applicable. Ash may be a hazardous waste.	RETAINED
		Asphalt Batching	Contaminated soils are incorporated into hot asphalt mixes as a partial substitute for stone aggregate. Majority of petroleum-based compounds are volatilized or incinerated during drying process. Remainder is fixed into final asphalt product.	Potentially applicated.	RETAINED

TABLE 5-14 (Continued). INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS (SOILS, SITE D-16)

SOIL GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	SCREENING COMMENTS	STATUS
Soil Removal/ Treatment (Con't)	Biological	Land Treatment	Excavated soils are mixed with native soils and nutrients are added to promote biological oxidation/degradation of petroleum-based compounds.	Potentially applicated.	RETAINED
	Solidification/ Stabilization	Sorption	Nonreactive nonbiodegradable solids are added to excavated soil to eliminate all free liquids.	Technology is applicable to solid wastes with a high percentage of liquids, it is, therefore, not applicable.	Rejected
		Lime/Fly Ash Pozzolan Process	Excavated soils are entrapped in a pozzolan concrete matrix.	Technology is applicable to solid wastes with a high percentage of liquids, it is, therefore, not applicable.	Rejected
		Pozzolan-Portand Cement Systems	Excavated soils are entrapped in a pozzolan concrete matrix.	Technology is applicable to solid wastes with a high percentage of liquids, it is therefore not applicable.	Rejected
		Thermoplastic Microencapsulation	Fine particles of excavated waste are mixed with melted asphalt.	Not applicable to wastes with VOC contamination.	Rejected
Treatment	In-Situ	Vapor Extraction	Volatile contaminants are removed through vacuum extraction wells.	Potentially applicable. Removes highly volatile contaminants located in the unsaturated zone.	RETAINED
		Biological	Microorganisms capable of degrading contaminants as well as nutrients and oxygen are added to soil.	Potentially applicable.	RETAINED
		Vitrification	Contaminated soil is melted in place to form a vitrified solid mass.	Only effective above water table to an approximate depth of 20 feet. Significant levels of silicates required. Contaminants are volatilized.	Rejected
		Soil Flushing	Soil is flushed with water or other detergent solutions to mobilize contaminants. The impregnated water is intercepted, collected and pumped to the surface for treatment.	Potentially applicable.	RETAINED
		Enhanced Volatilization	Contaminants are removed by mechanical aeration, air stripping, or low temperature thermal stripping.	Only low temperature thermal stripping has been shown effective. Field testing has been limited.	Rejected

TABLE 5-15. INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS (GROUNDWATER, SITES IS-1, SP-5/5A, SP-7/10, SP-15)

GROUNDWATER GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	SCREENING COMMENTS	STATUS
No Action	None	Not Applicable	No Action.	Required for consideration by NCP.	RETAINED
Institutional Controls	Groundwater Use Restrictions	None	Restrict groundwater usage in area of contamination.	Potentially applicable.	RETAINED
	Monitoring	Monitoring Wells	Ongoing monitoring of wells is conducted to determine concentration and direction of migrating contaminants.	Potentially applicable.	RETAINED
	Alternate Water Supply	Other Base Sources	Installation or expansion of other base water sources to service affected area.	Potentially applicable.	RETAINED
		City Water Supply	Extension of existing municipal well systems to serve affected area.	Potentially applicable.	RETAINED
Collection for Treatment and/or Discharge	Extraction	Extraction Wells	Series of wells to extract contaminated groundwater.	Potentially applicable.	RETAINED
		Extraction/Injection Wells	Injection wells inject uncontaminated water to increase flow of extraction wells.	Potentially applicable.	RETAINED
	Subsurface Drains	Interceptor Trenches	Perforated pipe in trenches backfilled with porous media to collect contaminated water.	Dependent upon groundwater level and other hydrogeologic criteria. Potentially applicable for some sites.	RETAINED
Direct Discharge	Onsite Discharge	Storm Sewer or Drainage Ditch	Extracted water discharged to storm sewer or drainage ditch.	Groundwater must be treated prior to discharge. Not acceptable.	Rejected
	Offsite Discharge	Deep Well Injection	Extracted water discharged to deep well injection system.	Deep aquifer not suitable for injection of contaminated water. Water supplies are located in deep aquifer.	Rejected
		POTW	Extracted water is discharged to a publicly owned treatment works.	Potentially applicable.	RETAINED
		Pipeline to Knik Arm	Extracted water discharged to Knik Arm.	Untreated water will not meet discharge requirements.	Rejected
		Recycle	Fuel removed from groundwater is recycled.	Potentially applicable.	RETAINED

TABLE 5-15 (Continued). INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS (GROUNDWATER, SITES IS-1, SP-5/5A, SP-7/10, SP-15)

GROUNDWATER GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	SCREENING COMMENTS	STATUS
Containment	Cover/Cap	Multi-Media Cap	Contaminated area is covered with clay followed by a synthetic membrane and a soil cover to reduce contaminant leaching due to surface water infiltration.	Capping is a viable alternative for containing source contamination within the vadose zone. However, no significant source contamination originating from the vadose zone was identified in the remedial investigation.	Rejected
	Vertical Barriers	Slurry Wall	Trench around area of contamination is filled with a soil (or cement) bentonite slurry to create a wall of low permeability and prevent plume migration.	Potentially applicable.	RETAINED
		Grout Curtain	Grout is pressure injected in a regular pattern of drilled holes to provide a low permeability barrier.	Generally incapable of attaining low permeabilities in unconsolidated materials.	Rejected
		Vibrating Beam	A vibrating force is used to advance beams into the ground with injection of slurry as beam is withdrawn.	Not feasible because of layers of large materials (cobbles) which would make installation difficult.	Rejected
Treatment	Biological Treatment	Aerobic Degradation	Degradation of organics using microorganisms in an oxygen containing environment.	Potentially applicable.	RETAINED
		Anerobic Digestion	Degradation of organics using microoganisms in an oxygen-free environment.	Potentially applicable.	RETAINED
	Chemical Treatment	Neutralization	Adjustment of pH by addition of acid or base.	Adjustment of pH is not required	Rejected
		Precipitation	Chemical equilibria of waste is changed to reduce solubility and precipitate undesired components.	Process is not effective in removing the contaminants of concern.	Rejected
		Ion Exchange	Selective removal of contaminant ions by exchange with other ions held on resin media.	Process is not effective in removing the contaminants of concern.	Rejected
		UV/Oxidation	Involves the addition of ozone and hydrogen peroxide into the waste stream followed by UV reaction to breakdown organic compounds.	Potentially applicable.	RETAINED

TABLE 5-15 (Continued). INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS (GROUNDWATER, SITES IS-1, SP-5/5A, SP-7/10, SP-15)

GROUNDWATER GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	SCREENING COMMENTS	STATUS
Treatment (Continued)	Physical Treatment	Fuel/Water Separation	Gravity separation is used to remove two immiscible phases with different densities.	Potentially applicable.	RETAINED
		Air Stripping	Air is contacted with groundwater in a packed tower to transfer volatile compounds from the liquid into the air.	Potentially applicable.	RETAINED
		Diffused Aeration	Groundwater is saturated with air. Floatation characteristics of contaminants are enhanced and VOCs are transferred to air.	Potentially applicable.	RETAINED
		Reverse Osmosis	Groundwater is passed through a semi-permeable membrane at high pressure to remove contaminants.	Waste stream may have adverse effects on the process. Technology will not remove contaminants of concern.	Rejected
		Carbon Adsorption	Involves adsorption of contaminants in groundwater onto granulated activated carbon.	Potentially applicable.	RETAINED
		Filtration	Groundwater is passed through a porous medium to remove suspended solids.	Process is not effective in removing the contaminants of concern.	Rejected
		Sedimentation	Gravity is used to remove suspended solids from the liquid phase.	Process is not effectiv in removing the contaminants of c	Rejected
	Thermal Destruction	Liquid Injection	Liquid waste is atomized, mixed with fuel, and combusted.	Potentially applicable.	RETAINED
		Rotary Kiln	Combustion of waste occurs in a horizontally rotating cylinder designed for uniform heat transfer.	Technology is primarily intended for solids combustion and therefore is not appropriate for the waste stream being treated.	Rejected
		Fluidized Bed	Waste is injected into a hot agitated bed of sand where combustion occurs.	Technology is primarily intended for slurries and sludges and therefore is not appropriate for the waste stream being treated.	Rejected
	Offsite Treatment	POTW	Extracted groundwater is discharged to a local POTW for treatment.	Concentrations of BETX contaminants in groundwater discharged to local POTW must be less than 0.1 mg/L (100 ug/L). BETX levels range from 970 ug/L at Site SP-15 to 60,600 ug/L at Site SP-5/5A.	Rejected

TABLE 5-15 (Continued). INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS (GROUNDWATER, SITES IS-1, SP-5/5A, SP-7/10, SP-15)

GROUNDWATER GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	SCREENING COMMENTS	STATUS
Treatment (Continued)	Offsite Treatment (Continued)	RCRA Facility	Extracted groundwater is discharged to a licensed RCRA facility for treatment and/or disposal.	Potentially applicable.	RETAINED
	In-Situ Treatment	Bioreclamation	System of injection and extraction wells introduce bacteria and nutrients to degrade contamination.	Groundwater temperatures become too low to sustain substantial biological growth.	Rejected
		Vapor Extraction	Volatile vapors are removed from soil by system of vacuum extraction wells.	Technology is applicable for removing VOC contaminants from unsaturated soils, but is not effective for groundwater remediation at Elmendorf AFB.	Rejected
		Permeable Treatment Beds	Downgradient trenches are backfilled with activated carbon to remove contaminants from groundwater.	Technology is applicable only in relatively shallow aquifers.	Rejected
		Chemical Reactions	System of injection wells introduce chemicals to oxidize contaminants.	Aquifer not suitable for injection of potentially hazardous chemicals.	Rejected
		Vitrification	Waste is melted in place to form a vitrified solid mass.	Technology is primarily intended for treatment of soil and is not appropriate for the waste stream being treated.	Rejected
Discharge of Treated Water	Onsite Discharge	Storm Drain	Treated water is discharged to storm drain.	Potentially applicable.	RETAINED
		Drainage Ditch	Treated water is discharged to drainage ditch.	Potentially applicable.	RETAINED
		Well Injection	Extracted water discharged back into aquifer to increase flow of extraction wells.	Potentially applicable.	RETAINED
	Offsite Discharge	POTW	Treated water discharged to POTW.	Potentially applicable.	RETAINED
		Pipeline to Knik Arm	Extracted water is discharged to Knik Arm via a newly constructed pipeline.	Potentially applicable.	RETAINED
		Recycle	Fuel phase removed from groundwater is recycled.	Potentially applicable.	RETAINED

- The potential effectiveness in protecting human health and the environment.

- How proven and reliable the process is with respect to the contaminants and conditions at the site.

Each process was also evaluated on its technical implementability. This evaluation focuses on the institutional aspects of implementability, such as the ability to obtain necessary permits and the availability of treatment, storage, and disposal facilities.

Finally, the cost of each process option was judged to be low, medium, or high relative to other process options in the same technology type. Processes which were considered much more costly than others but offered no substantial increase in protection of public health or the environment were eliminated.

The results from the screening are summarized in Tables 5-16 and 5-17 for soil and groundwater remediation respectively.

5.2.6 Development of Remedial Alternatives

The technologies which have successfully passed the screening in the previous section are now assembled into alternatives to address the remedial objectives for each site. A summary of the alternatives is presented in Table 5-18. The alternatives formulated provide a range of waste cleanup options from no action to complete treatment of the hazardous constituents under consideration. The NCP identifies 5 categories under which at least 1 alternative should be developed, to the extent that it is possible and appropriate. The categories are:

TABLE 5-16. FURTHER SCREENING OF PROCESS OPTIONS (SOILS, SITE D-16)

SOIL GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	EFFECTIVENESS	IMPLEMENTABILITY	COST	STATUS
No Action	None	No Applicable	Does not achieve remedial action objectives. Required for consideration by NCP.	Not acceptable to local/ public government.	None	RETAINED
Institutional Controls	Access Restriction	Fencing	Effective in preventing direct contact with contaminants. Does not reduce contamination.	Easily implemented. Restrictions on future land use.	Low capital. Low maintenance.	RETAINED
	Monitoring	Groundwater Monitoring	Useful in documenting conditions. Does not reduce risk.	Alone, not acceptable to public/local government.	Low capital. Low maintenance.	RETAINED
Containment	Cover/Cap	Clay/Soil	Effective in minimizing contact with contaminants, but susceptible to cracking.	Easily implemented. Restricts future land use.	Low capital. Moderate maintenance.	Rejected
		Multi-layer	Most effective, least susceptible to cracking.	Easily implemented. Restricts future land use.	Moderate capital. Moderate maintenance.	RETAINED
	Vertical Barriers	Slurry Wall	Effectively reduces groundwater flow in areas of unconsolidated materials, best when used with other containment. Slurry wall should be keyed into impervious layer. More applicable to groundwater remediation than soil.	Difficult to implement in areas of high relief or areas with large subsurface materials (cobbles and and boulders).	Moderate capital. Low maintenance.	Rejected
Soil Removal/ Disposal	Excavation	Excavation	Effective and reliable.	Easily implemented	Moderate capital.	RETAINED
	Onsite Disposal	Onsite RCRA-Permitted Landfill	Effective and reliable.	Difficult to implement because of permitting restrictions.	High capital. High maintenance.	Rejected
	Offsite Disposal	Sanitary Landfill	Effective and reliable at removing contamination at the site. Does not destroy contaminants.	Easily implemented, wastes must meet landfill's contaminant limitations.	Moderate capital.	RETAINED
		RCRA-Permitted Landfill	Effective and reliable.	Difficult to implement, no RCRA-Permitted facilities in Alaska, must haul wastes to lower 48 states.	High capital.	RETAINED (To be considered only if further analysis indicate that soil is a hazardous waste.)

TABLE 5-16 (Continued). FURTHER SCREENING OF PROCESS OPTIONS (SOILS, SITE D-16)

SOIL GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	EFFECTIVENESS	IMPLEMENTABILITY	COST	STATUS
Soil Removal/ Treatment	Excavation	Excavation	Effective and reliable.	Easily implemented.	Moderate capital.	RETAINED
	Thermal	Rotary Kiln	Effective for destruction of organics. Inorganic ash requires treatment or disposal at a RCRA-permitted facility if ash cannot be delisted. Minimal reduction in volume of waste.	Implementable, but no units available in Alaska.	High capital.	RETAINED (To be considered only if further analysis indicates that soil is a hazardous waste.)
		Asphalt Batching	Unproven that all contaminants are volatilized, incinerated, or fixed into product. Presence of volatiles or large soil particles in final product can compromise product quality.	Implementable, but asphalt production facility must be retrofitted to incorporate soils. Soil storage, leachate collection, and leachate treatment/disposal facilities necessary. Increased air emission control or monitoring may be necessary. Contaminated soil fraction generally must be less than 5 percent of total aggregate feed.	High capital.	Rejected
	Biological	Land Treatment	Effective for volatilization and degradation of organics.	May not be implementable due to extreme weather conditions.	Moderate capital. High maintenance.	Rejected
Treatment	In-Situ Treatment	Vapor Extraction	Effective for removal of volatile organic components from unsaturated zone.	Easily implemented where groundwater table is not excessively shallow.	Low capital. Low maintenance.	RETAINED
		Biological	Effective for degradation of organics.	May not be implementable due to extreme weather conditions.	Moderate capital. High maintenance.	Rejected
		Soil Flushing	Potentially effective for removal of organic components, but unproven.	Potentially implementable.	High capital. Moderate maintenance.	Rejected

TABLE 5-17. FURTHER SCREENING OF PROCESS OPTIONS (GROUNDWATER, SITES IS-1, SP-5/5A, SP-7/10, SP-15)

GROUNDWATER GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	EFFECTIVENESS	IMPLEMENTABILITY	COST	STATUS
No Action	None	Not Applicable	Does not achieve remedial objectives. Required for consideration by NCP.	Not applicable to local/public government.	None	RETAINED
Institutional Controls	Groundwater Use Restrictions	None	Protects users from ingesting contaminated groundwater. No contaminant reduction.	Requires approval by Elmendorf AFB.	Negligible	RETAINED
	Monitoring	Monitoring Wells	Useful for monitoring plume migration. Does not reduce exposure risk.	Easily implemented.	Low capital. Low O&M.	RETAINED
	Alternate Water Supply	City Water Supply	Prevents ingestion of contaminated water. No contaminant reduction.	Difficult to implement. Piping long distances required. Local approval required.	High capital. Low O&M.	Rejected
		Other Base Sources	Prevents ingestion of contamination. No contaminant reduction.	Easily implemented. Requires approval of AFB.	Low capital. Low O&M.	RETAINED
Collection for Treatment and/or Discharge	Extraction	Extraction Wells	Effective means of removing groundwater and controlling plume migration.	Easily implemented.	Moderate capital. Moderate O&M.	RETAINED
		Extraction/ Injection Wells	Effective means of increasing flow to extraction wells. However, well pumping rates are already high at Elmendorf.	Permit required.	Moderate capital. Moderate O&M.	Rejected
	Subsurface Drains	Interceptor Trenches	Requires shallow aquifer. Effective in containing seep area at Site SP-5/5A.	Easily implemented.	High capital. Moderate O&M.	RETAINED
Direct Discharge	Offsite Discharge	POTW	Pretreatment of groundwater may be required before POTW can effectively treat and reduce contamination.	Permit required. Must meet pretreatment regulations.	High capital. High O&M.	Rejected
		Recycle	Effective means of reusing fuel removed from groundwater.	Readily implementable. Base services available.	Negligible.	RETAINED
Containment	Vertical Barriers	Slurry Walls	Effectively contains groundwater plume.	Very difficult to implement at Elmendorf. Sections of runway or streets cannot be excavated. Underground fuel lines present a major problem.	High capital. Low O&M.	Rejected

TABLE 5-17 (Continued). FURTHER SCREENING OF PROCESS OPTIONS (GROUNDWATER, SITES IS-1, SP-5/5A, SP-7/10, SP-15)

GROUNDWATER GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	EFFECTIVENESS	IMPLEMENTABILITY	COST	STATUS
Treatment	Biological Treatment	Aerobic Degradation	Effectiveness depends on many variables such as dissolved oxygen, nutrient concentration, temperature, pH, salinity, and contaminant types and concentration. Other destruction processes are available which do not pose as many limitations or variables.	Implementable. Discharge permit required.	Moderate capital. High O&M.	Rejected
		Anerobic Digestion	Effectiveness has same limitations as described for aerobic treatment.	Implementable. Discharge permit required.	Moderate capital. High O&M.	Rejected
	Chemical Treatment	UV/Oxidation	Effectively and reliably destroys contaminants. Technology is relatively new for site remediation.	Readily implementable. Discharge permit required.	High capital. Moderate O&M.	RETAINED
	Physical Treatment	Fuel/Water Separation	Effective and reliable method of removing pure product from groundwater.	Readily implementable.	Low capital. Moderate O&M.	RETAINED
		Air Stripping	Effective and reliable. Conventional technology. Portable units are available.	Readily implementable. Discharge permit required. Height limitations apply close to runway.	Moderate capital. Moderate O&M.	RETAINED
		Diffused Aeration	Basically accomplishes same result as air stripping but is less efficient.	Readily implementable. Discharge permit required.	Moderate capital. Moderate O&M	Rejected
		Carbon Adsorption	Effective and reliable. Conventional technology. Portable units are available.	No local TSD facilities available for waste carbon. RCRA permit required for disposal.	Moderate capital. High O&M.	RETAINED
	Thermal Destruction	Liquid Injection	Effective and reliable method of destroying contaminants.	Implementable	Very high capital and O&M.	RETAINED
	Offsite Treatment	RCRA Facility	Effective and reliable method of treatment and disposal.	Difficult to implement. There are no RCRA-permitted facilities in Alaska. Waste must be hauled long distances to RCRA-permitted facilities.	Very high capital and O&M.	Rejected
Discharge of Treated Water	Onsite Discharge	Storm Drain	Effective and reliable.	Readily implementable.	Moderate capital. Low O&M.	RETAINED

TABLE 5-17 (Continued). FURTHER SCREENING OF PROCESS OPTIONS (GROUNDWATER, SITES IS-1, SP-5/5A, SP-7/10, SP-15)

GROUNDWATER GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	EFFECTIVENESS	IMPLEMENTABILITY	COST	STATUS
Discharge of Treated Water (Con't)	Onsite Discharge (Con't)	Drainage Ditch	Freezing of surface water may result from cold winter conditions.	Implementable.	Moderate capital. Low O&M.	Rejected
		Recharge Well Injection	Effective means of increasing flow to extraction wells. However, well recovery rates are already high at Elmendorf.	Permits required.	Moderate capital. Moderate O&M.	Rejected
	Offsite Discharge	POTW	Effective and reliable.	Implementable. Permit required.	Moderate capital. Very high O&M.	Rejected
		Pipeline to Knik Arm	Effective and reliable alternative to storm drain.	Implementable. Permit required.	High capital. Low O&M.	RETAINED

TABLE 5-18. ALTERNATIVES REMAINING AFTER PRELIMINARY SCREENING

Alternative Number	Alternative Description	Environmental Media	NCP Category	SARA Category
1	No Action	Soil and Groundwater	1	1
2	Groundwater Monitoring, Groundwater Use Restrictions, Alternate Water Supply	Groundwater	4	N/A
3	Collection, Onsite Air Stripping, Surface Discharge	Groundwater	3	3
4	Collection, Onsite Carbon Adsorption, Surface Discharge	Groundwater	3	3
5	Collection, Onsite Liquid Injection, Offsite Solids Disposal	Groundwater	3	3
6	Collection, Onsite UV/Oxidation, Surface Discharge	Groundwater	3	3
7	Containment by Surface Capping	Soil	4	2
8	Onsite Vapor Extraction	Soil	4	3
9	Excavation and Offsite Sanitary Landfill Disposal	Soil	3	4
10	Excavation and Offsite RCRA-Permitted	Soil	3	4
11	Excavation and Offsite Incineration	Soil	3	3

1. No action alternative.
2. Alternatives that attain ARARs. (ARARs were presented in Section 5.1.)
3. Alternatives that exceed ARARs.
4. Alternatives that do not attain ARARs.
5. Alternatives for treatment or disposal at an offsite facility.

Section 121 of SARA states that emphasis should be placed on employing technologies which reduce toxicity, mobility, or volume of contaminants and on remedial actions that utilize permanent solutions. Alternatives developed under SARA should cover the following categories:

1. No action alternative.
2. A containment alternative that reduces toxicity, mobility, or volume of the contaminants.
3. Treatment alternatives that reduce toxicity, mobility, or volume of the contaminants.
4. Alternatives that eliminate the need for long-term management, including monitoring.

A total of eleven preliminary alternatives were developed to address the remedial action objectives and satisfy the criteria for alternative categories. The (National Oil and Hazardous Substances Contingency Plan (NCP) and SARA category for each alternative is listed in Table 5-18.

A brief description of each alternative is provided below. In addition to describing the alternative, consideration is given to the technical advantages or limitations of each alternative. This

information will be used to screen the alternatives in the next section. The alternatives are described in general terms so that the alternative description can be applied to a number of sites. However, if variations in alternatives are required due to individual site conditions, these variations are also discussed.

5.2.6.1 Alternative 1 - No Action (Groundwater and Soil)

The no action alternative is developed for use as a baseline against which the effectiveness of other alternatives can be compared. Under the no action alternative, no new or additional remedial activities will be conducted at the site. Furthermore, no funds will be expended for monitoring, control, or remediation of contamination at the site. The no action alternative is applicable to all sites (D-16, IS-1, SP-5/5A, SP-7/10, SP-15). This alternative falls under category 1 of SARA and the NCP.

5.2.6.2. Alternative 2 - Groundwater Monitoring, Groundwater Use Restrictions, Alternate Water Supply (Groundwater)

Under this alternative, active drinking water wells in the general direction of plume migration are monitored quarterly for volatile organics. In the event that VOCs are detected near or above minimum drinking water standards, the well will be taken out of service and an alternate supply provided. In addition, the installation of any new wells in the affected area, for purposes other than monitoring will be prohibited.

This alternative will also include continued groundwater monitoring at selected locations. The objective of groundwater monitoring in this alternative is to further assess the spatial extent of the plume and to determine the direction and rate of contaminant migration. The information gained from continued monitoring will be used to evaluate

the potential risks imposed on drinking water supplies and on surface waters by the migrating plume.

Alternative 2 is applicable to sites IS-1, SP-5/5A, SP-7/10, and SP-15. The alternative falls under category 4 of the NCP.

5.2.6.3 Alternative 3 - Collection, Onsite Air Stripping, Surface Discharge (Groundwater)

Under this alternative, groundwater is pumped from a series of extraction wells and collected for onsite treatment. The extraction wells will be located in strategic positions at each site to capture and contain the migrating plume. Groundwater containing free floating fuel product will be pretreated for fuel/water separation before entering the air stripping tower. The fuel phase will be recovered and recycled by Defense Reutilization and Marketing Office (DRMO). The pretreated water is then combined with water from other extraction wells and pumped to an air-stripping tower for removal of the remaining volatile hydrocarbons dissolved in the water. In the air stripping unit, large volumes of air are contacted with the contaminated liquid to desorb volatile components from the liquid and reabsorb them into the contacting air. The air is then discharged into the atmosphere and the treated water is discharged to surface waters. Air stripping is a proven and reliable method for removing the volatile hydrocarbons of concern at each site.

The proposed discharge of treated water is to Knik Arm via storm drains located on the base. A National Pollutant Discharge Elimination System (NPDES) permit will be required for discharge in this manner. The contaminants in the off-gases from the air stripping unit will contain volatile organics. Currently, there are no state standards regulating the concentration of off-gases from these units, other than threshold limit values (TLVs) for gases in occupied areas

(proposed State of Alaska regulations, see Appendix Q). Therefore, it is expected that off-gases will be discharged without secondary treatment. In the event that treatment is required, technologies such as vapor phase carbon adsorption or catalytic combustion can be incorporated into the system. Secondary treatment of off-gases will not be included in the cost evaluation. This alternative also includes installation of additional groundwater monitoring wells and subsequent monitoring of groundwater and monitoring of treated liquid effluent to evaluate system performance.

Alternative 3 is applicable to all FS sites except D-16 where groundwater remediation is not being addressed. The collection system at Site SP-5/5A will be modified to include interceptor trenches as well as extraction wells for the collection of groundwater. Interceptor trenches will be effective in capturing fuel which has been observed seeping from the hillside.

This alternative falls under category 3 of both SARA and the NCP.

5.2.6.4 Alternative 4 - Collection, Onsite Carbon Adsorption, Surface Discharge (Groundwater)

In this alternative collection, pretreatment, and discharge are the same as described for Alternative 3. Removal of the dissolved organic contaminants is accomplished by adsorption onto fixed beds of granulated activated carbon. Treatment with activated carbon is a well established technology and has shown good performance and reliability in removing the groundwater contaminants of concern at each of the FS sites.

One disadvantage associated with activated carbon is that large volumes of spent carbon are generated from the process which must be disposed of as hazardous waste material or regenerated. Therefore,

the depleted carbon will have to be transported offsite to an approved RCRA facility for regeneration or disposal. Since there are currently no RCRA facilities of this type in Alaska, the spent carbon will have to be shipped long distances to an acceptable site in the lower forty-eight states.

This alternative will include groundwater monitoring to assess the movement of the plume and the level of contaminant reduction during remedial action. Also, an NPDES permit will be required for effluent discharge as well as monitoring of effluent quality during system operation. Alternative 4 is applicable to all FS sites except Site D-16. The alternative falls under category 3 of both SARA and the NCP.

5.2.6.5 Alternative 5 - Collection, Onsite Liquid Injection, Offsite Solids Disposal (Groundwater)

Under this alternative, collection and pretreatment are the same as described for Alternative 3. Pretreated groundwater is pumped to an onsite liquid injection treatment unit. The process provides complete thermal destruction of the organic compounds and has the advantage of producing no liquid effluent for discharge. The treatment process does, however, release off-gases which would require monitoring and also generates small volumes of ash for disposal. For the purpose of performing preliminary cost evaluations, the treatment of off-gases will be considered unnecessary and the disposal costs of residual ash product negligible.

As with other treatment alternatives, Alternative 5 will also include groundwater monitoring during remedial action. However, unlike the other treatment processes, thermal injection will not require a permit for discharge of liquid effluent. Alternative 5 is applicable to all sites except site D-16. The alternative falls under category 3 of both SARA and the NCP.

5.2.6.6 Alternative 6 - Collection, Onsite UV/Oxidation, Surface Discharge (Groundwater)

In this alternative, collection, pretreatment, and surface discharge are the same as described in Alternative 3. Treatment of the organic compounds dissolved in groundwater is accomplished by a destruction process utilizing ozone gas and ultraviolet (UV) light. The pretreated liquid is pumped to a reaction vessel where ozone gas and hydrogen peroxide are added as strong oxidizing agents to react with and break down the organic contaminants of concern. Additional energy for the reaction is provided by UV lamps.

The advantage of this treatment process is that essentially complete conversion of organic contaminants to carbon dioxide and water can be achieved. The off-gases from the reactor pass through a catalytic ozone decomposer unit which reduces ozone levels to acceptable air quality standards. UV/Oxidation has demonstrated successful treatment of groundwater containing the contaminants of concern present at each FS site.

An NPDES permit will be required to discharge liquid effluent to waters of the United States. Monitoring of treated water is required to evaluate treatment efficiency and meet NPDES permit requirements. Also, monitoring wells will be installed to assess the movement of the plume and the level of contamination reduction during remedial action.

This alternative is applicable to all FS sites except Site D-16. The alternative falls under category 3 of both SARA and the NCP.

5.2.6.7 Alternative 7 - Containment by Surface Capping (Soil)

This alternative utilizes soil capping technology to prevent contact with and minimize migration of contaminants. The surface of the

contaminated area is capped with a soil-synthetic membrane to eliminate direct human exposure to surface soils and prevent the infiltration of precipitation and subsequent leaching of contaminants from the soils. The alternative also includes site security fencing and groundwater monitoring.

Restrictions on the use and development of the site will be required because contaminants are left in place. Use restrictions are also required to maintain the integrity of the cap. The site will also be fenced to effectively eliminate the potential for direct contact with surface contaminants. Capping Site D-16 reduces leaching of contaminants into the groundwater and minimizes the potential for contaminant migration by surface runoff. In addition, groundwater monitoring at the site provides the information necessary to determine whether or not groundwater has been contaminated, and if so, the potential for offsite migration.

This alternative is applicable to soils at Site D-16 and falls under category 2 of SARA and category 4 of the NCP.

5.2.6.8 Alternative 8 - Onsite Vapor Extraction (Soil)

Under this alternative, volatile soil contaminants are removed by an in-situ vapor extraction system. The system basically consists of vapor extraction wells, air inlet wells, and vacuum pumps or air blowers. Extraction wells are spaced from 15 to 100 feet apart and are typically designed to fully penetrate the unsaturated zone to the capillary fringe. Air inlet wells are also installed to control air flow through zones of maximum contamination and promote horizontal air flow to the extraction wells. With this configuration, fresh air is allowed to flow into the subsurface at locations around the disposal

site, and vapor-laden air is withdrawn under vacuum from the extraction wells. After extraction, the vapor-laden air is discharged to the atmosphere.

Vapor extraction is most suitable for removal of volatile organics contained in unsaturated soils. The rate of vapor removal is expected to be primarily affected by the chemicals volatility, its sorptive capacity onto soils, air flow rate, the distribution of air flow, the initial distribution of contaminants, soil stratification or aggregation, and soil moisture content. Compounds exhibiting vapor pressures over 0.5 mm mercury can most likely be extracted with soil air. When expressed in terms of the air-water partitioning coefficient, compounds which have values of dimensionless Henry's Law constants greater than 0.01 are more likely to be removed in vapor extraction systems. Most constituents of gasoline fuels can be successfully removed under the right soil conditions. However, the technology is not effective in removing heavier petroleums fuels, oils, and lubricants (Hutzler, 1988). Vapor extraction also has very limited performance capabilities for removing soluble fuel components from groundwater (personal communication with Jim Hayden, ADEC, 1989 and Glynn and Ducheseau, 1988).

Alternative 8 also includes fencing and groundwater monitoring as described under Alternative 7. The alternative is applicable to remediation of soils at Site D-16 and falls under category 3 of SARA and category 4 of the NCP.

5.2.6.9 Alternative 9 - Excavation and Offsite Sanitary Landfill Disposal (Soil)

This alternative employs conventional earth moving equipment such as bulldozers, scrapers, front-end loaders, backhoes, and dump trucks to remove contaminated soil. The excavated soil is transported to an

appropriate landfill for disposal. The Anchorage Regional Landfill will accept soils containing up to 1000 ppm TPH, but will not accept hazardous waste. Therefore, if additional analyses of the soil do not detect hazardous substances above the allowable concentration limits, the soil can be disposed of in the local sanitary landfill. The excavated area at Site D-16 will be backfilled with uncontaminated native soil. The alternative also includes groundwater monitoring on a short term basis. Monitoring will be conducted to determine if groundwater has been contaminated. If groundwater at Site D-16 is contaminated, the feasibility of remediating the groundwater will be evaluated.

This alternative is applicable to Site D-16 and falls under category 4 of SARA and category 3 of the NCP.

5.2.6.10 Alternative 10 - Excavation and Offsite RCRA-Permitted Landfill Disposal (Soil)

Like the previous alternative, conventional excavation equipment is used to remove soils at site D-16. However, under this alternative, soils are transported to an approved RCRA-permitted facility for disposal. Because the State of Alaska has no RCRA-permitted facilities, contaminated soils will be transported to one of the lower forty-eight states for disposal at approved locations. This alternative should only be considered if additional analyses indicate that contaminant constituents and concentrations designate the soils as hazardous waste.

Alternative 10 includes groundwater monitoring as described under Alternative 9 and is only applicable to Site D-16. This alternative falls under category 4 of SARA and category 3 of the NCP.

5.2.6.11 Alternative 11 - Excavation and Offsite Incineration (Soil)

This technology also employs conventional earth moving equipment such as bulldozers, scrapers, front-end loaders, backhoes, and dump trucks to remove and transport contaminated soil. Incineration involves the use of heat to destroy organic contaminants. The necessary equipment can be located at an offsite commercial facility or mobile equipment can be brought to the site. Commercially available, thermal treatment processes such as rotary kiln incineration have been successfully used for the destruction of organic wastes. Hazardous inorganic materials such as lead, which are not destroyed by the process may have to be disposed as hazardous wastes if found at significant concentrations in the ash product. Only 20 to 30 percent volume reduction is achieved by incinerating soil. Therefore, if the ash is a hazardous waste and must be disposed of in a RCRA-permitted landfill, 70 to 80 percent of the total volume of excavated soil must still be landfilled. Permitting requirements can delay startup of incinerators if they are to be installed onsite. As was the case for Alternative 10, this alternative should only be considered if additional soil analyses indicate that contaminant constituents and concentrations designate the soils as hazardous waste.

This alternative is only applicable to Site D-16. Alternative 11 falls under category 4 of SARA and category 3 of the NCP.

5.3 INITIAL SCREENING OF ALTERNATIVES

The alternatives assembled in the previous section undergo preliminary screening in this section. The objective of alternative screening is to narrow the list of potential alternatives that will be evaluated in detail. In order to make accurate comparisons between individual alternatives, the following three basic criteria are used: public health and environmental impacts, technical feasibility, and cost. By applying the 3 criteria, alternatives are screened and the total quantity of options to be considered in detail is reduced, while still

maintaining a range of remedial options to select from. The screening analysis is provided in detail below. A summary of results from the screening analysis is presented at the end of this section in Table 5-25.

5.3.1 Public Health/Environmental Impacts

The main objective of the remedial action is to protect human health and the environment. The basic elements of this criteria are summarized below:

- The alternative should prevent exposure to contamination by direct contact or ingestion.

- The alternative should prevent further migration of contamination to other areas offsite or off-Base. The alternative should also prevent migration of contaminant from 1 environmental medium to another such as from soil to groundwater or groundwater to surface water.

- The alternative should also improve the quality of the contaminated medium by reducing contaminants to target cleanup levels.

The ability of individual alternatives to meet or fail the above criteria has been evaluated and is summarized in Table 5-19.

As shown in Table 5-19 , the no action alternative fails to meet each of the 3 criteria for protection of public health and the environment. Therefore, the no action alternative is not acceptable for remedial action for each of the sites considered in the FS. Alternative 2 involves quarterly monitoring of drinking water wells and therefore

TABLE 5-19. SUMMARY OF PUBLIC HEALTH AND ENVIRONMENTAL IMPACT SCREENING

Alternative	Media of Concern	Prevents Exposure to Contamination	Prevents Further Migration of Contamination	Reduces Contaminants to Target Cleanup Levels
1	Soil and Groundwater	No	No	No
2	Groundwater	Yes	No	No
3	Groundwater	Yes	Yes	Yes
4	Groundwater	Yes	Yes	Yes
5	Groundwater	Yes	Yes	Yes
6	Groundwater	Yes	Yes	Yes
7	Soil	Yes	Partially*	No
8	Soil	Yes	Yes	Yes
9	Soil	Yes	Yes	Yes
10	Soil	Yes	Yes	Yes
11	Soil	Yes	Yes	Yes

*Reduces, but does not eliminate, potential for leaching of contaminants.

substantially reduces the possibility of ingesting contaminated water supplies. However, the alternative does not provide removal or reduction of groundwater contaminants nor does it limit migration. Alternative 7, which involves capping only, does not meet the criteria of reducing the contaminants to target cleanup levels; however, it does prevent exposure and minimizes the potential for leaching contaminants into the groundwater or surface water. Alternatives 9 and 10, while providing removal of the contaminated soil at site D-16 by excavation and offsite landfilling, do not address the treatment of soils directly. The 2 alternatives do, however, reduce soil contaminants to target cleanup levels at the site and also prevent exposure and further migration of contaminants offsite. All other alternatives that involve onsite treatment of the contaminated media satisfy the three criteria for public health and environmental impacts.

5.3.2 Technical Feasibility

The main screening criteria for technical feasibility are summarized as follows:

- The ability of the alternative to reach remedial objectives in a reasonable time frame.
- The ability to obtain permits and the availability of treatment/disposal facilities.
- The proven performance and reliability of the technology in meeting remedial objectives.

The technical feasibility aspects of each alternative were discussed briefly during the description of alternatives (Section 5.2.6). Technical feasibility is not pertinent to the no action alternative since no remedial technologies are involved. Alternatives 2 and 7 do

not provide removal or treatment of the contaminants, and therefore do not reach target cleanup levels in a reasonable time frame. Alternatives 9, 10, and 11 involve direct excavation and removal of contaminated soil at Site D-16 and all are expected to require a similar time frame to reach cleanup objectives. Sufficient information is not available to calculate accurate cleanup times for pump and treatment methods (alternatives 3, 4, 5, and 6). However, it is expected that each alternative will require similar cleanup times to reach remedial objectives for groundwater.

The ability to obtain permits and the availability of treatment/disposal facilities was discussed briefly in Section 5.2.6 for each alternative. Alternative 4 involves the use of activated carbon which requires offsite disposal or regeneration of the spent material in a RCRA-permitted facility. Since there are currently no licensed facilities in the state of Alaska that can accept this material, the spent carbon would have to be transported long distances to another state for disposal or regeneration. It is possible to regenerate the carbon onsite, however, this would require an additional treatment step and a new set of permits. Alternative 10 faces a similar problem since excavated soils must be landfilled in RCRA-permitted facility. Alternative 11 which involves incineration of soils may also require disposal in a RCRA-permitted facility if by-product ash is determined to be a hazardous waste. All other alternatives for groundwater and soil remediation do not require the use of an offsite RCRA-permitted treatment/disposal facility.

In consideration of the proven reliability and performance of each technology in meeting remedial objectives, all alternatives which involve treatment of groundwater have been demonstrated to be successful and reliable cleanup at sites where the same type and relative concentration of contamination has occurred. The limitations of vapor extraction for cleanup of soils at Site D-16 were discussed

in section 5.2.6.8 for Alternative 8. While this technology has been demonstrated successfully in the cleanup of volatile fuel components in soil, it does not provide acceptable cleanup performance for heavier, less volatile fuels, oil, and lubricants which are present at the site. Incineration and landfilling, on the other hand, are well demonstrated and reliable technologies for soil remediation.

5.3.3 Cost Screening

For the purpose of preliminary screening, rough cost estimates have been calculated for each alternative on a site by site basis. The objective of the cost screening is to eliminate alternatives that have costs greatly exceeding those of other equally effective alternatives. The capital cost, operation and maintenance cost, and present worth for each alternative for each site are summarized in Tables 5-20 to 5-24. The goal established by FS guidance documents in calculating these costs is to be accurate within -50 percent to +100 percent. Costs are based on the most-probable site conditions which were developed and summarized in Section 5.2.3, Table 5-9 through 5-13. For all alternatives involving pump and treat methods or excavation of soils, an average project life of 3 years was used as the estimated time to reach completion of the remedial action from treatment plant startup. Alternatives 2 and 7 involve long term monitoring and therefore a project life of 20 years has been used. Since volumes and areas of contamination are not fully understood or developed at this stage for most sites, actual cleanup times and costs may vary as more detailed information is obtained.

5.3.4 Summary of Screening

The results from initial screening of alternatives in this section are summarized in Table 5-25. A brief explanation for eliminating or retaining alternatives is also provided.

TABLE 5-20. SUMMARY OF PHASE II ALTERNATIVE COSTS: SITE D-16

Alternative	Remedial Action	Capital Cost ($1000s)	Annual Cost ($1000s)	Present Worth[(1)] ($1000s)
1	No Action	0	0	0
7	Containment By Surface Capping	840	6.8	901[(2)]
8	Onsite Vapor Extraction	1,355	4.8	1,367
9	Excavation, Offsite Sanitary Landfill Disposal	1,918	5.8	1,932
10	Excavation, Offsite RCRA-Permitted Landfill Disposal	8,766	5.8	8,781
11	Excavation, Offsite Incineration	49,773	5.8	49,788

Notes: (1) Present worth calculated using 9.375% interest for a three-year project life.

(2) Present worth calculated for 20 year life due to containment, not removal, of contamination.

TABLE 5-21. SUMMARY OF PHASE II ALTERNATIVE COSTS: SITE IS-1

Alternative	Remedial Action	Capital Cost ($1000s)	Annual Cost ($1000s)	Present Worth[1] ($1000s)
1	No Action	0	0	0
2	Groundwater Monitoring, Use Restrictions, Alternate Water Supply	27.5	29.0	285[2]
3	Collection, Onsite Air Stripping, Surface Discharge	560	59.1	509
4	Collection, Onsite Carbon Adsorption, Surface Discharge	723	149	1,100
5	Collection, Onsite Liquid Injection, Surface Discharge	3,000	3,100	10,800
6	Collection, UV/Oxidation, Surface Surface Discharge	859	245	1,470

NOTES: (1) Present worth calculated using 9.375% interest for a three-year project life.
(2) Cost for monitoring all sites quarterly for 20 years.

TABLE 5-22. SUMMARY OF PHASE II ALTERNATIVE COSTS: SITE SP-5/5A

Alternative	Remedial Action	Capital Cost ($1000s)	Annual Cost ($1000s)	Present Worth[1] ($1000s)
1	No Action	0	0	0
2	Groundwater Monitoring, Use Restrictions, Alternate Water Supply	27.5	29.0	285[2]
3	Collection, Onsite Air Stripping, Surface Discharge	2,830	49.6	2,950
4	Collection, Onsite Carbon Adsorption, Surface Discharge	3,030	319	3,830
5	Collection, Onsite Liquid Injection, Surface Discharge	4,760	2,090	10,000
6	Collection, UV/Oxidation, Surface Surface Discharge	3,250	141	3,610

NOTES: (1) Present worth calculated using 9.375% interest for a three-year project life.
(2) Cost for monitoring all sites quarterly for 20 years.

TABLE 5-23. SUMMARY OF PHASE II ALTERNATIVE COSTS: SITE SP-7/10

Alternative	Remedial Action	Capital Cost ($1000s)	Annual Cost ($1000s)	Present Worth[1] ($1000s)
1	No Action	0	0	0
2	Groundwater Monitoring, Use Restrictions, Alternate Water Supply	27.5	29.0	285[2]
3	Collection, Onsite Air Stripping, Surface Discharge	464	57.1	609
4	Collection, Onsite Carbon Adsorption, Surface Discharge	1,280	326	2,100
5	Collection, Onsite Liquid Injection, Surface Discharge	3,410	4,160	13,900
6	Collection, UV/Oxidation, Surface Surface Discharge	1,190	200	1,690

NOTES: (1) Present worth calculated using 9.375% interest for a three-year project life.
(2) Cost for monitoring all sites quarterly for 20 years.

TABLE 5-24. SUMMARY OF PHASE II ALTERNATIVE COSTS: SITE SP-15

Alternative	Remedial Action	Capital Cost ($1000s)	Annual Cost ($1000s)	Present Worth[1] ($1000s)
1	No Action	0	0	0
2	Groundwater Monitoring, Use Restrictions, Alternate Water Supply	27.5	29.0	285[2]
3	Collection, Onsite Air Stripping, Surface Discharge	254	35.1	343
4	Collection, Onsite Carbon Adsorption, Surface Discharge	638	36.3	729
5	Collection, Onsite Liquid Injection, Surface Discharge	1,870	947	4,260
6	Collection, UV/Oxidation, Surface Surface Discharge	571	63.1	730

NOTES: (1) Present worth calculated using 9.375% interest for a three-year project life.
(2) Cost for monitoring all sites quarterly for 20 years.

TABLE 5-25. INITIAL SCREENING OF ALTERNATIVES (Sites D-16, IS-1, SP-5/5A, SP-7/10, SP-15)

Alternative	Description	Retained	Eliminated	Reason for Elimination or Retention
1	No Action. (Groundwater & Soil)	X		Required by the NCP and SARA for baseline alternative.
2	Well Monitoring, Groundwater Use Restrictions, Alternate Water (Groundwater)	X		Prevents ingestion of contaminated drinking water. Does not contain or reduce contaminant levels. Retained to provide a range of remedial options.
3	Collection, Onsite Air Stripping, Surface Discharge (Groundwater)	X		Meets remedial objectives. Well established and reliable technology.
4	Collection, Onsite Carbon Adsorption, Surface Discharge (Groundwater)		X	No acceptable waste treatment/disposal facilities available in the state for waste carbon. Transporta-tion costs for waste are high.
5	Collection, Onsite Liquid Injection, Offsite Solids Disposal (Groundwater)		X	Cost greatly exceeds those of other equally effective alternatives.
6	Collection, Onsite UV/Oxidation, Surface Discharge (Groundwater)	X		Meets remedial objectives. Can pro-vide complete destruction of contami-nants of concern.
7	Containment by Surface Capping (Soil)	X		Meets all screening criteria except criteria for improving quality of contaminated medium. Retained to provide a range of remedial options.
8	Onsite Vapor Extraction (Soil)		X	Not applicable for removing soil contaminants with low vapor pressure.
9	Excavation, Offsite Local Landfill (Soil)	X		Meets all screening criteria. Local landfill is available for soils with TPH below 1,000 ppm.
10	Excavation, Offsite RCRA-Permitted Landfill (Soil)	X		Meets all screening criteria. Retained as an option for Alternative 9.

TABLE 5-25. INITIAL SCREENING OF ALTERNATIVFS (Sites D-16, IS-1, SP-5/5A, SP-7/10, SP-15)

Alternative	Description	Retained	Eliminated	Reason for Elimination or Retention
11	Excavation, Offsite Incineration (Soil)		X	Meets remedial objectives. Provides treatment and destruction of contaminants. Costs greatly exceed Alternative 10 which is equally effective.

5.4 DESCRIPTION OF REMEDIAL ALTERNATIVES FOR DETAILED EVALUATION

This section presents detailed descriptions of the 7 remedial alternatives remaining after initial screening in Section 5.3. A summary of remaining alternatives and the specific media and sites to which they apply is provided in Table 5-26. The descriptions in this section provide sufficient information required to perform the detailed evaluation of alternatives in the next section.

The descriptions of each alternative includes a discussion of key technologies and other elements which comprise the alternative. Site layouts, process diagrams (where appropriate), operational requirements, and the degree to which the alternative meets the remedial action objectives for the site are also provided. A technology that is common to more than one alternative is explained in detail under the first alternative it is used. Descriptions of subsequent alternatives that include the same technology reference back to the earlier description. Alternatives for groundwater remediation are described in general terms to address a number of sites. However, site specific detail is provided where appropriate.

5.4.1 Alternative 1 - No Action (Soil and Groundwater)

The no action alternative is the baseline against which the effectiveness of other alternatives are judged. The alternative is required by the NCP and SARA. Under the no action alternative, no funds are expended for monitoring, control, or remediation of the contamination. The site is simply left in its present condition with no remedial action taken to minimize or reduce impacts on public health and the environment. The no action alternative does not prevent migration of contamination or improve the quality of soils and groundwater already contaminated. This alternative is applicable to all sites evaluated in the FS.

TABLE 5-26. SUMMARY OF ALTERNATIVES RETAINED FOR DETAILED ANALYSIS

ALTERNATIVE	D-16	IS-1	SP-5/5A	SP-7/10	SP-15
1 - No Action	X	X	X	X	X
2 - Groundwater Monitoring, Groundwater Use Restrictions, Alternative Water Supply (Groundwater)		X	X	X	X
3 - Collection, Onsite Air Stripping, Surface Discharge (Groundwater)		X	X	X	X
6 - Collection, Onsite UV/ Oxidation, Surface Discharge (Groundwater)		X	X	X	X
7 - Containment by Surface Capping (Soil)	X				
9 - Excavation, Offsite Local Landfill (Soil)	X				
10 - Excavation, Offsite RCRA Landfill (Soil)	X				

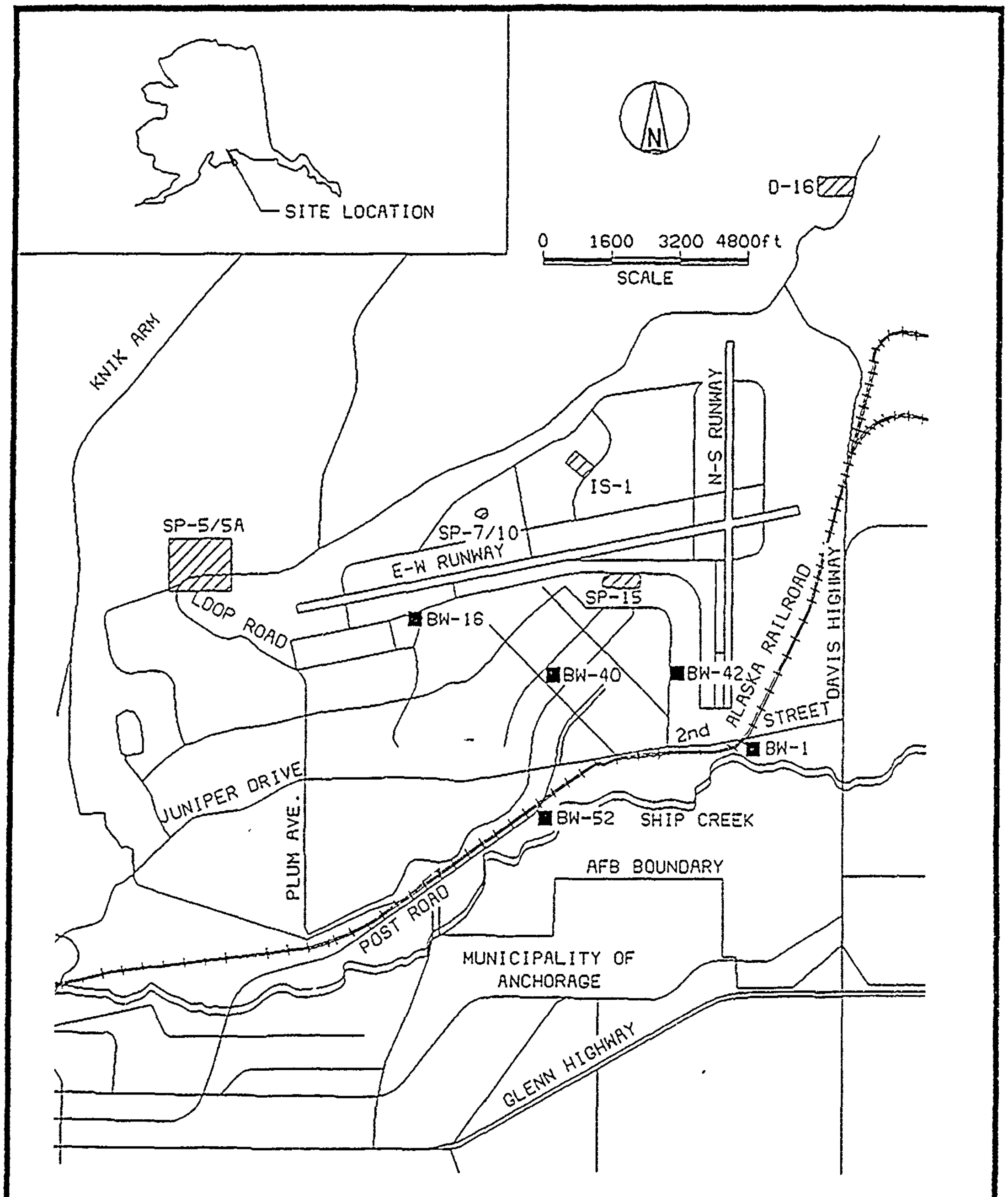
5.4.2 Alternative 2 - Groundwater Monitoring, Groundwater Use Restrictions, Alternate Water Supply (Groundwater)

The major components of this alternative include additional groundwater monitoring at each site, monitoring of active drinking water wells for volatile contaminants, groundwater use restrictions, and provision of an alternate water supply if necessary.

Elmendorf AFB derives the majority of its water supply from the Ship Creek reservoir at Fort Richardson. The active groundwater wells on the base which are connected to the central utility system are only used to supplement the main water supply. The location of active base wells which could potentially be impacted from sites evaluated in the FS are shown on Fig. 5-6. Table 5-27 provides specific information on each well system.

The sites which could have the greatest potential impact on drinking water quality by migration of contaminated groundwater are Sites IS-1, SP-7/10, and SP-15. The groundwater flow from each site is in the south/southwest direction. Drinking water sources in the most direct path of groundwater flow are base wells 16, 40, and 42. As shown in Table 5-27, each of these wells has been completed at a depth of greater than 200 feet into an artesian aquifer. If groundwater contamination is limited to the shallow aquifer, the artesian wells will probably not be impacted by migrating plumes. Base well number 1 is located in the shallow aquifer (16 feet deep) and therefore has a greater probability of risk from contaminants migrating in the shallow aquifer. However, the well is located to the southeast and away from flow gradient.

In this alternative, active base wells 1, 16, 40, and 42 will be sampled periodically for VOCs. The Air Force has already scheduled base well 40 for quarterly sampling of VOCs. In the event that VOCs



LEGEND

BW-1 BASE WELL

D-16 SITE LOCATION

BASE WELL

LOCATIONS

IRP Stage 3 RI/FS
Elmendorf AFB, AK

Figure
5-6

TABLE 5-27. ACTIVE DRINKING WATER WELL LOCATIONS

Well	Building	Depth (ft)	Aquifer	Yield (gpm)	Condition	Class
1	23-990	16	S	1,350	In Use	A
2	22-001	850	A	840	In Use	A
16	32-189	228	A	95	In Use	A
40	5-800	209	A	228	In Use	A
42	11-200	225	A	139	In Use	A
52	23-100	166	A	36	In Use	A

A = Artesian

S = Shallow

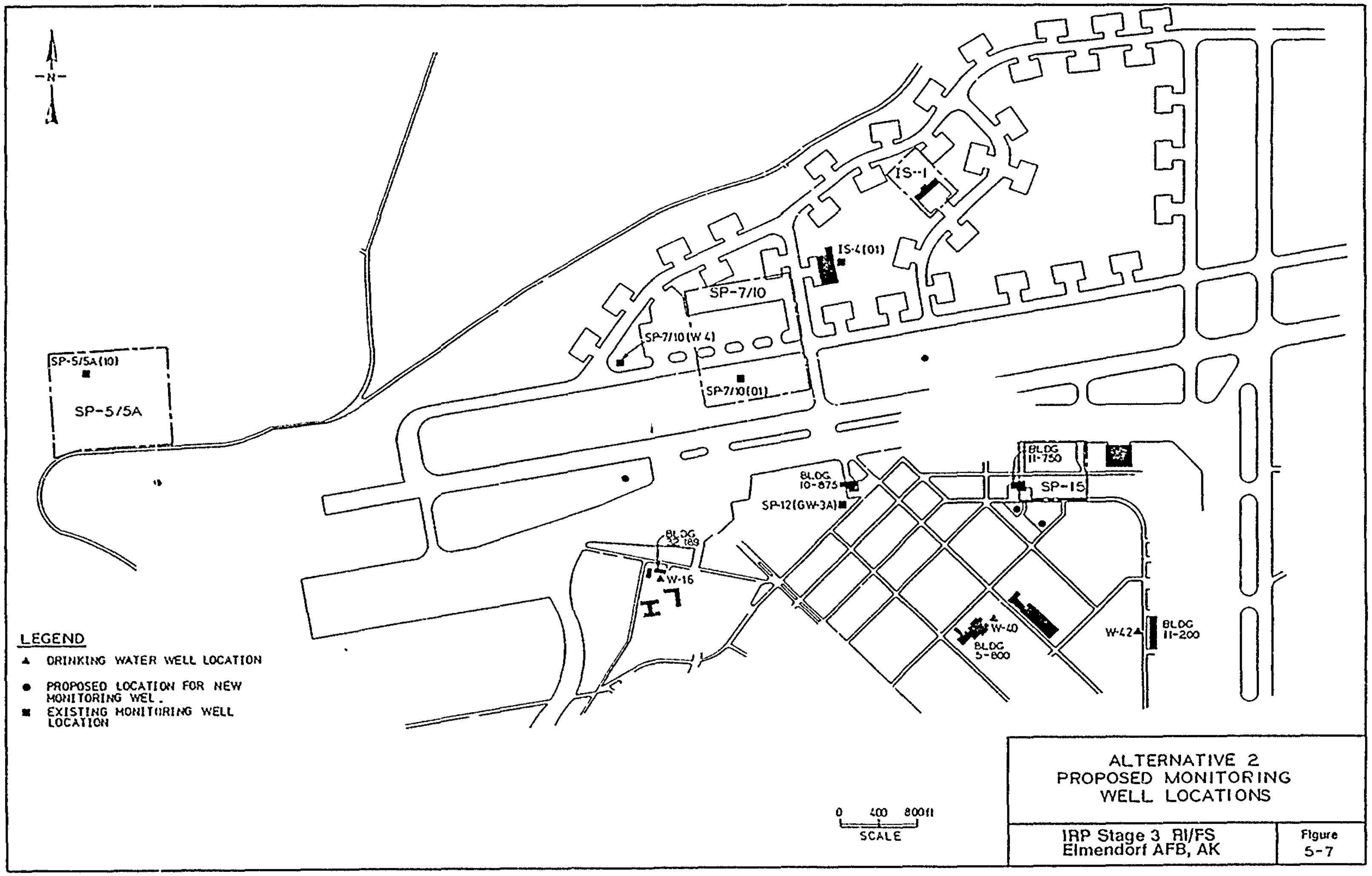
Class A - Greater than 25 users.

are detected near or above minimum drinking water standards, the well will be taken out of service and the central utility system supply will become the only source of drinking water for the affected area. In addition, the installation of any new wells in the affected area, for purposes other than monitoring, will be prohibited. If continued groundwater monitoring indicates plume movement toward base wells 2 and 52, then quarterly monitoring will also be initiated for these wells.

In addition to sampling drinking water supply wells, this alternative will also involve sampling of groundwater monitoring wells. The proposed locations for groundwater monitoring wells are shown on Figure 5-7. The existing monitoring wells sampled in the RI that will be used as a part of the remedial action are also shown on the figure. The primary purpose of groundwater monitoring is to provide an early indication that drinking water supplies may be adversely impacted. Each monitoring well location has been selected based on the most probable flow direction of contaminants originating from individual sites and on the location of base wells.

The monitoring well locations are intended to intercept potential plumes migrating toward base drinking water sources. The monitoring system will also provide data to better assess the potential impacts on surface waters in Ship Creek and Cherry Hill Ditch.

The installation of monitoring wells will basically follow the same methods used in the RI. A typical monitoring well design is shown in Fig. 5-8. Each well is screened to a minimum of 10 feet and a maximum of 20 feet using slotted PVC pipe. The screened section is extended at least 8 feet below and 2 feet above the static water level. This will allow for the collection of any floating contaminants. Monitoring wells near the runway at Site SP-7/10 will be installed flush with the ground in compliance with Air Force requirements. For

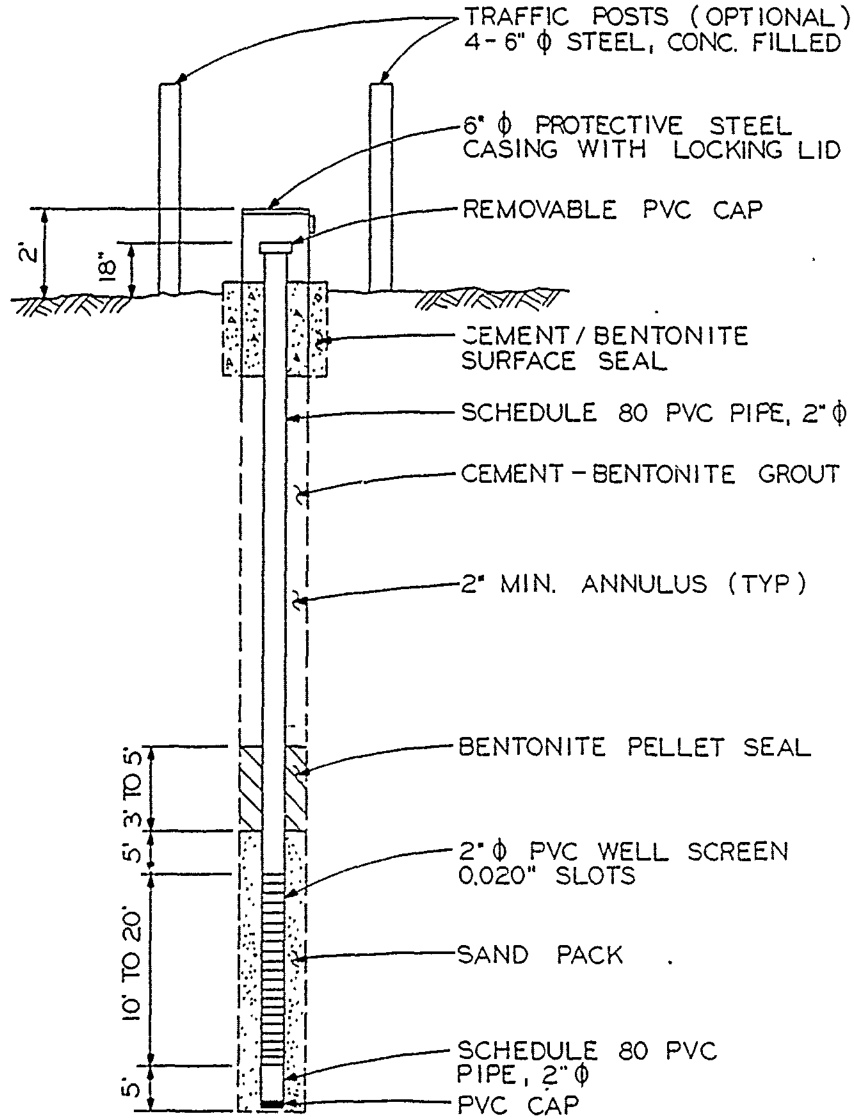


LEGEND
▲ DRINKING WATER WELL LOCATION
● PROPOSED LOCATION FOR NEW MONITORING WEL.
■ EXISTING MONITORING WELL LOCATION

ALTERNATIVE 2
PROPOSED MONITORING
WELL LOCATIONS

IRP Stage 3 RI/FS
Elmendorf AFB, AK

Figure
5-7



NOT TO SCALE

TYPICAL MONITORING WELL DESIGN

IRP Stage 3 RI/FS
Elmendorf AFB, AK

Figure 5-8

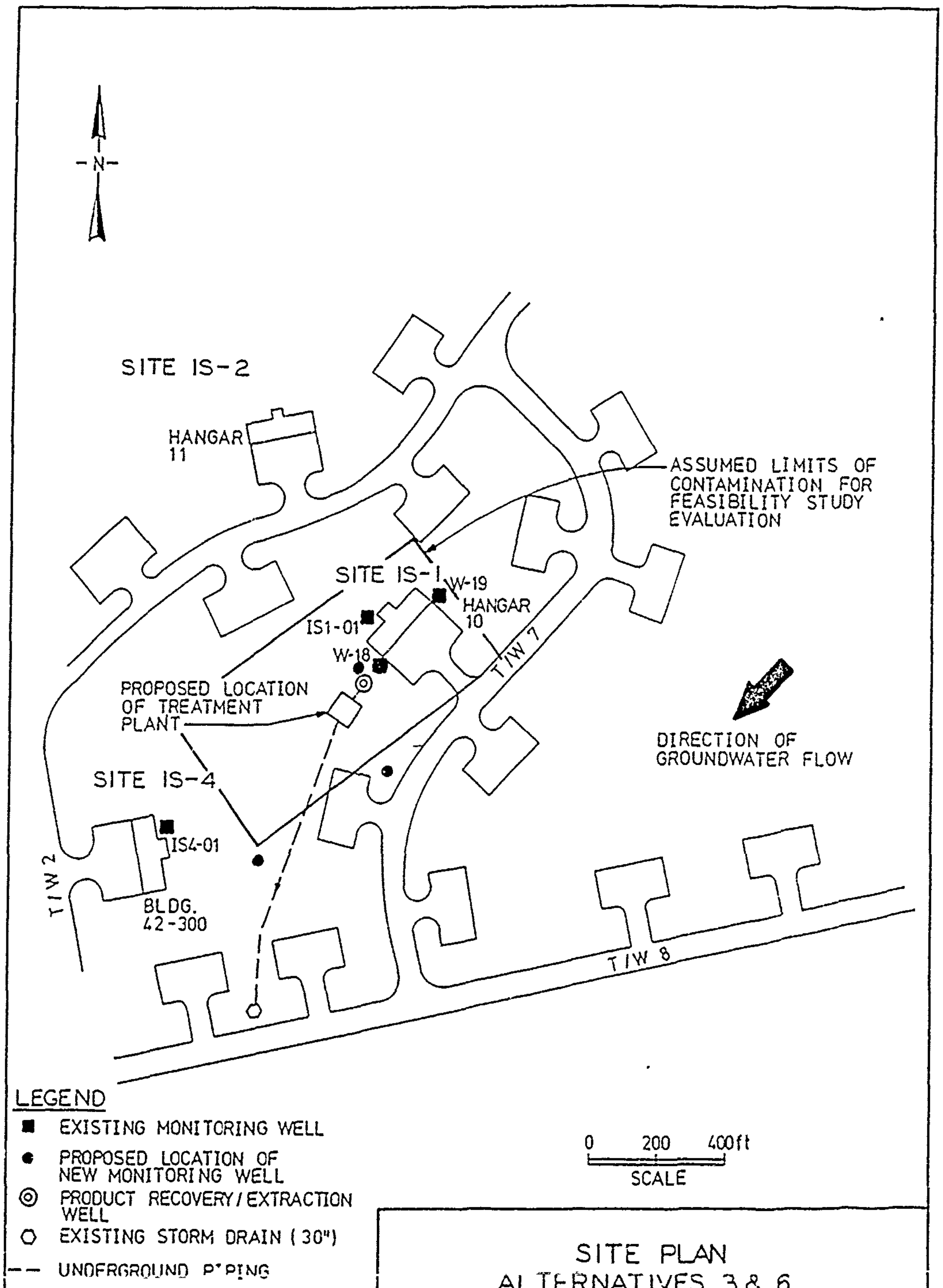
purposes of evaluating costs it will be assumed that each monitoring well will be sampled quarterly for VOCs for a period of 20 years.

This alternative is applicable to Sites IS-1, SP-5/5A, SP-7/10, and SP-15.

5.4.3 Alternative 3 - Collection, Onsite Air Stripping, Surface Discharge (Groundwater)

The primary elements of this alternative include collection and containment of the groundwater plume by pumping from extraction wells, pretreatment to remove free floating fuel product, treatment of the groundwater by onsite air stripping, discharge of the treated effluent to local storm drains, and monitoring of groundwater to determine plume migration and performance of the remedial action.

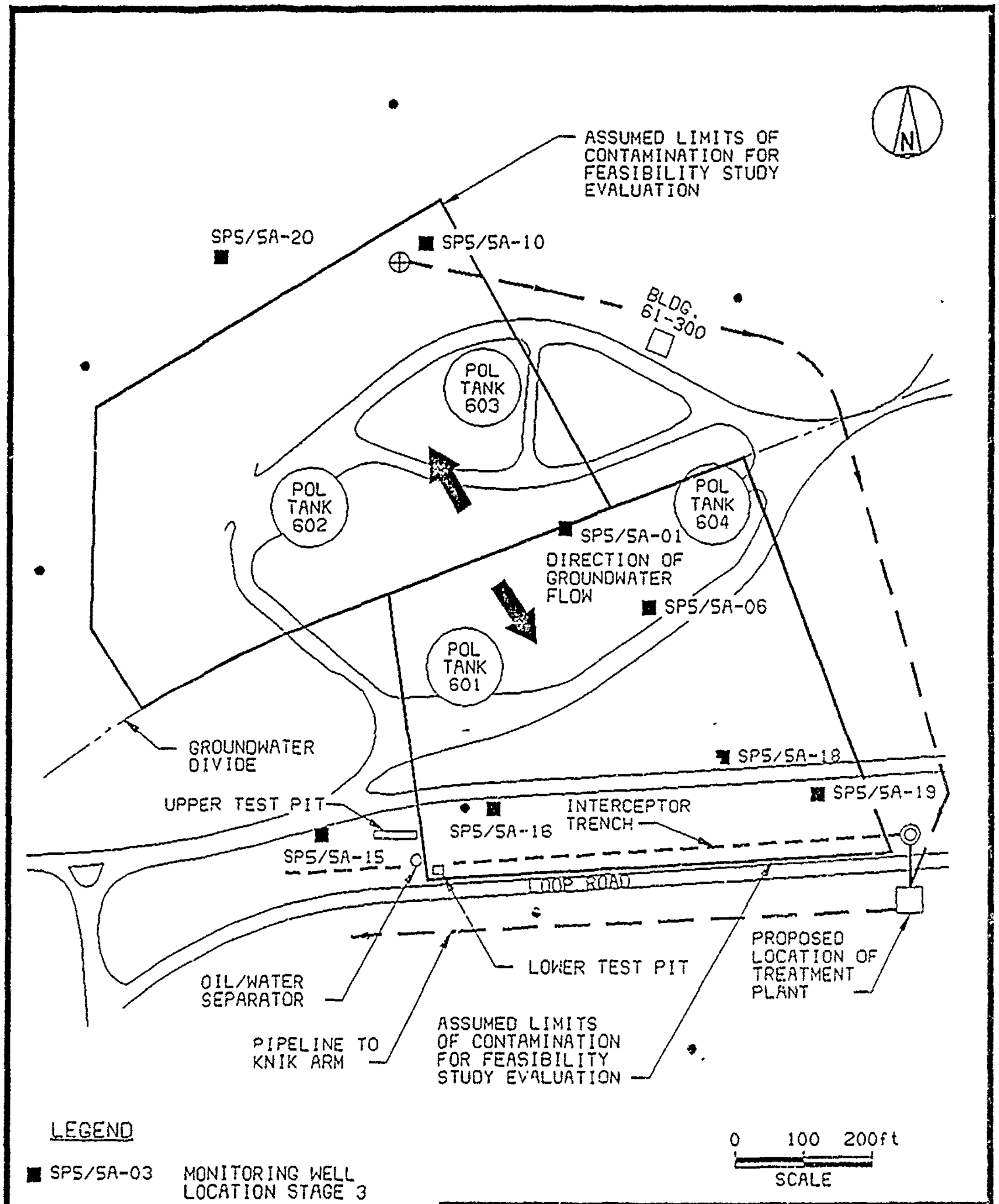
Groundwater extraction wells are located at each site as shown on the Site Plans (Figures 5-9 to 5-12). The purpose of the extraction system is to collect water for onsite treatment and to prevent further migration of contaminated groundwater by intercepting and containing the plume within specific boundaries. In selecting locations for the optimum placement of extraction wells, a number of critical factors must be considered such as plume dimensions, hydrogeologic characteristics, and well hydraulics. In many cases, sufficient data was not available from the RI to fully assess the most optimum placement of extraction wells at a given site. For example, the groundwater sampling from the 2 monitoring well locations at Site SP-15 did not provide enough information to accurately establish plume dimensions or the actual contamination source point. In situations where sufficient information was not available, the most probable site conditions were selected as the basis for purposes of evaluating alternatives. The most probable conditions for each site were discussed in Section 5.2.3 and summarized in Tables 5-9 through 5-13.



SITE PLAN
ALTERNATIVES 3 & 6
SITE IS-1

IRP Stage 3 RI/FS
Elmendorf AFB, AK

Figure
5-9



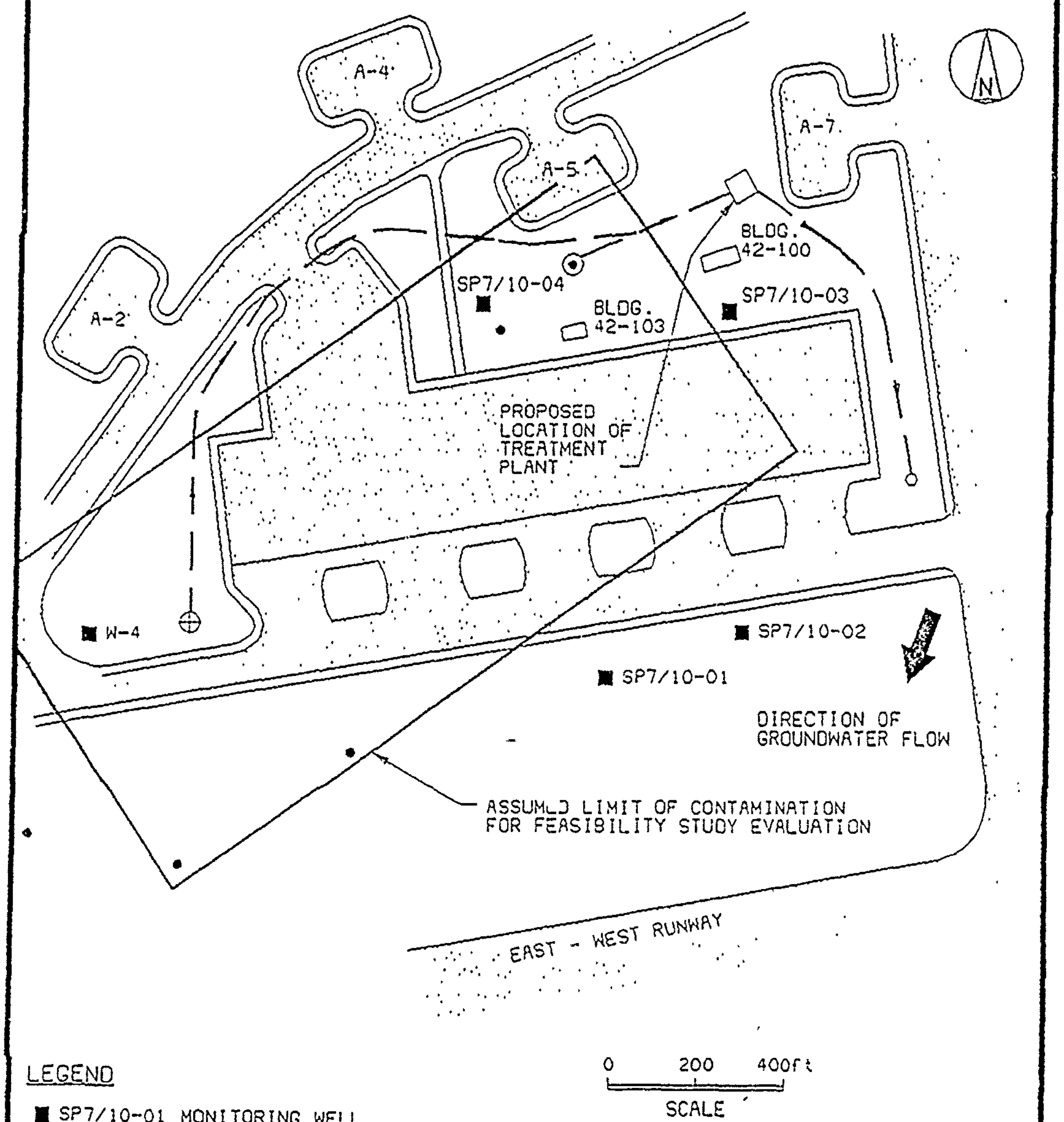
LEGEND

SP5/5A-03	MONITORING WELL LOCATION STAGE 3
•	PROPOSED LOCATION, STAGE 4 MONITORING WELL
⊕	EXTRACTION WELL
◎	WET WELL
— — —	UNDERGROUND PIPING

SITE PLAN
ALTERNATIVES 3 & 6
SITE SP-5/5A

IRP Stage 3 RI/FS
Elmendorf AFB, AK

Figure 5-10



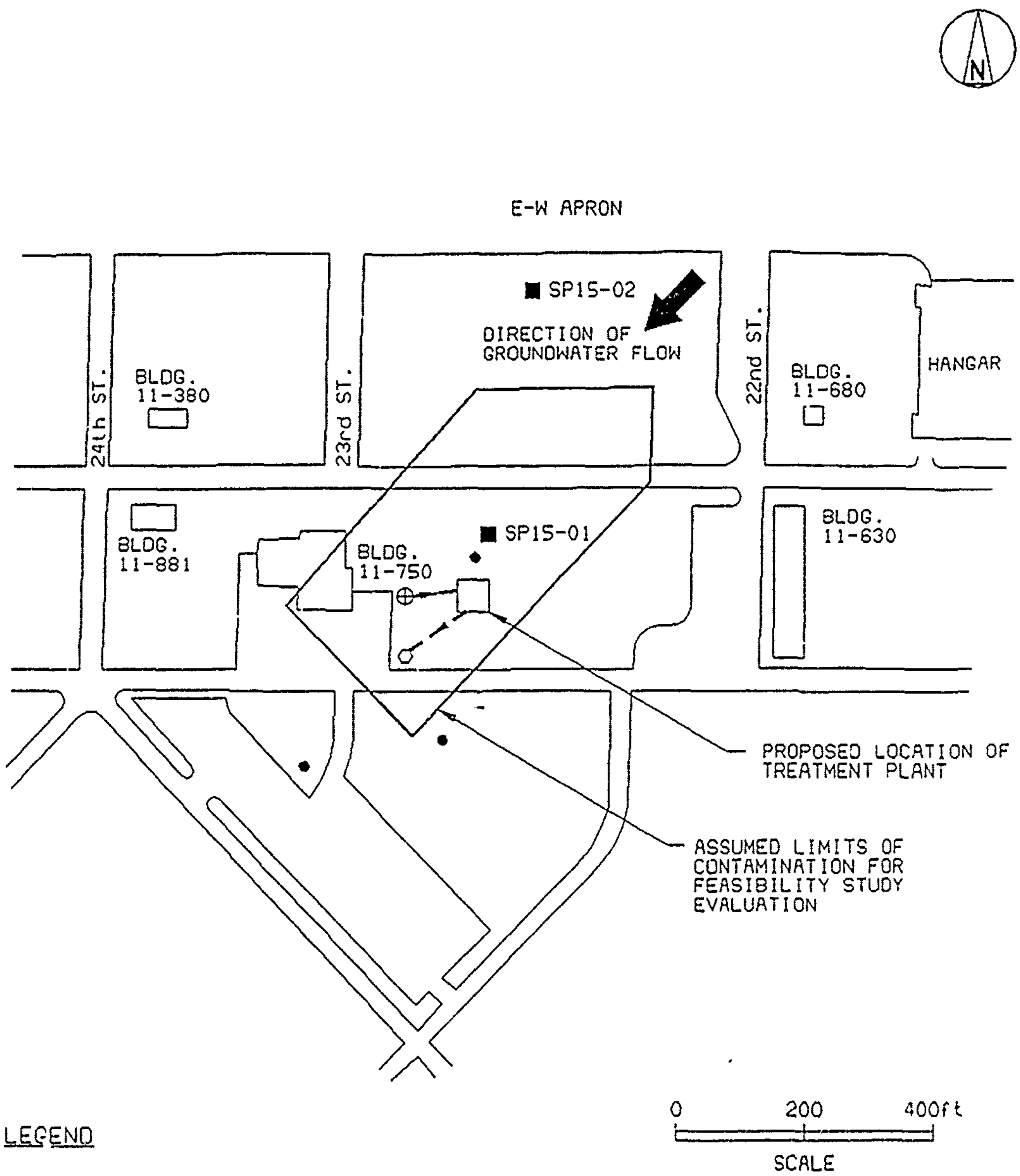
LEGEND

- SP7/10-01 MONITORING WELL LOCATION STAGE 3
- PROPOSED LOCATION, STAGE 4 MONITORING WELL
- ASPHALT
- EXTRACTION WELL
- PRODUCT RECOVERY/ EXTRACTION WELL
- EXISTING STORM DRAIN (30" DIA)
- UNDERGROUND PIPING

SITE PLAN
ALTERNATIVES 3 & 6
SITE SP-7/10

IRP Stage 3 RI/FS
Elmendorf AFB, AK

Figure 5-11



LEGEND

■ SP15-1	MONITORING WELL LOCATION STAGE 3
•	PROPOSED LOCATION, STAGE 4 MONITORING WELL
⊕	EXTRACTION WELL
○	EXISTING STORM DRAIN (12" DIA)
— —	UNDERGROUND PIPING

SITE PLAN
ALTERNATIVES 3 & 6
SITE SP-15

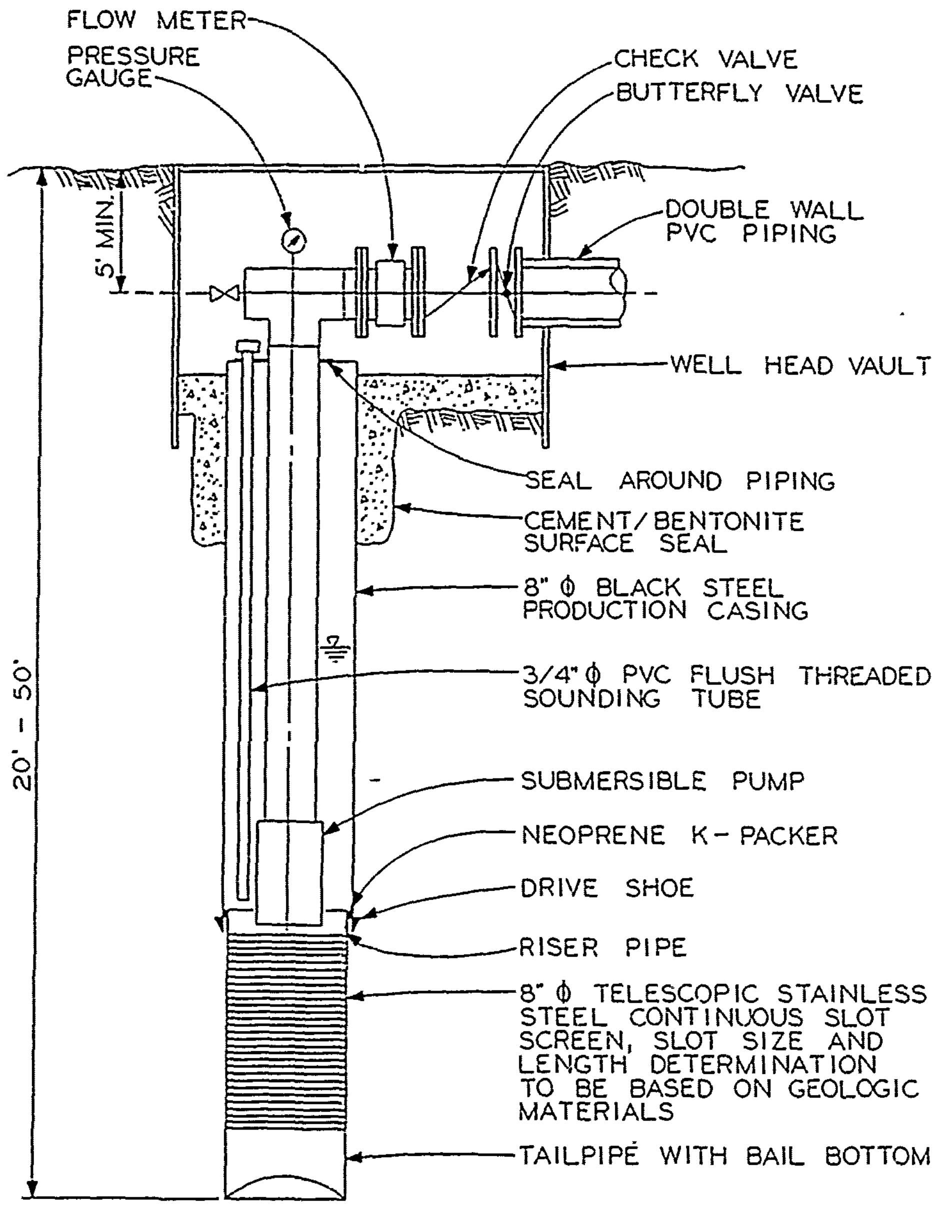
IRP Stage 3 RI/FS
Elmendorf AFB, AK

Figure 5-12

A typical extraction well system with major components is shown in Figure 5-13. Each well is constructed with an 8-inch diameter casing and completed with stainless steel continuous slot screen. Well flowrates will vary from site to site. Specific flowrates and estimated times to cleanup the groundwater to target levels are given in Table 5-28. The screened depth into the aquifer will range from 10 feet to 20 feet. The piping from the extraction well will run underground at a minimum depth of 5 feet to prevent freezing. Piping will be constructed with double walls to contain leaks that may develop.

Product recovery systems will be located near wells where free floating product was observed in groundwater samples taken during the RI. The specific locations of product recovery systems are identified in Figures 5-9 through 5-12. Recovery of the fuel product is an important first step in groundwater remediation, since the free floating fuel represents a concentrated source of BETX contaminants. Removal of the product at the beginning of remediation reduces volatilization of the product into the surrounding soil and reduces the further dissolution of BETX contaminants into groundwater, thus reducing the total time and cost of cleanup.

The basic elements of the fuel recovery system are shown in Figure 5-14. Extraction of the fuel phase is accomplished with a dual pumping system which utilizes a water table depression pump (groundwater extraction pump) in combination with a fuel recovery pump. The inlet of both pumps are located in the same 8-inch diameter well. The depression pump inlet is located below the fuel/water interface and serves to create a depression cone which draws the concentrated plume toward the well and allows fuel product to accumulate more rapidly. At the same time, the recovery pump inlet is immersed in the floating fuel layer and pure product is drawn to the surface for recovery. Conductivity sensors are used to control



TYPICAL EXTRACTION WELL DESIGN ALTERNATIVE 3 & 6

IRP Stage 3 RI/FS
Elmendorf AFB, AK

Figure 5-13

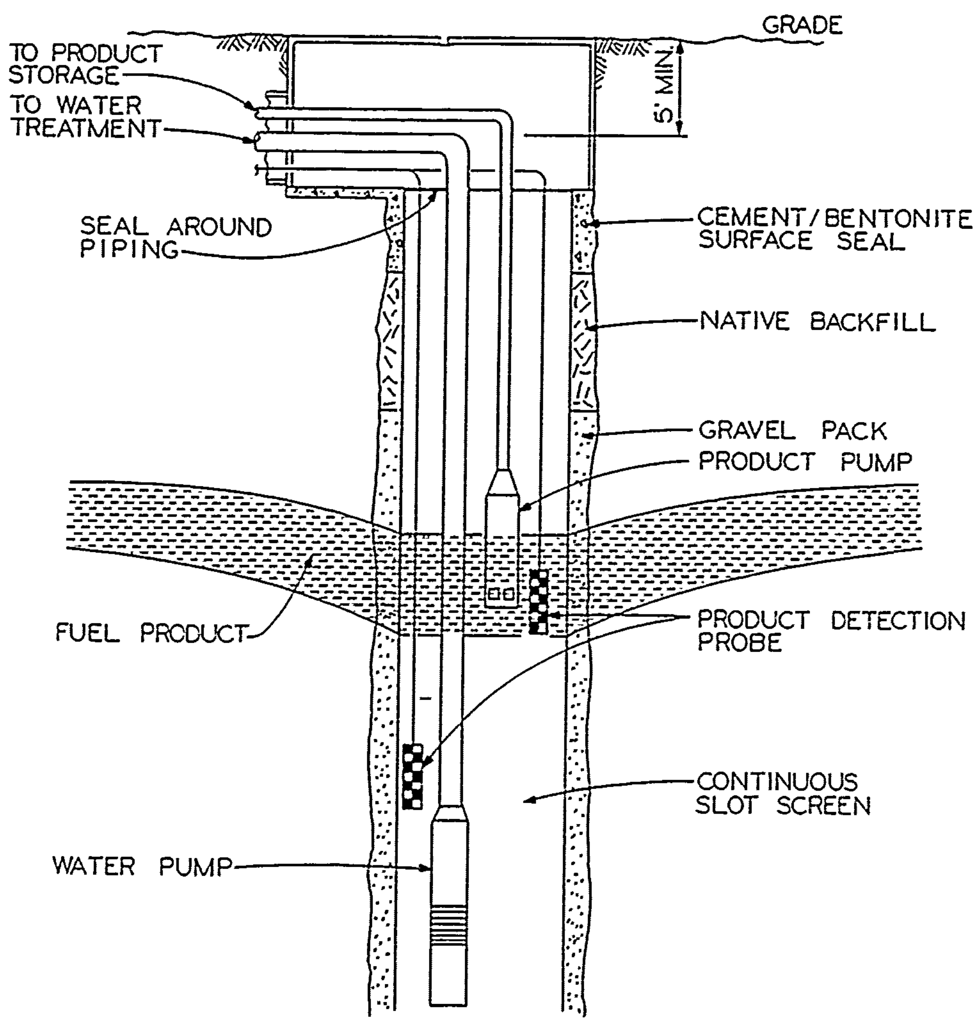
TABLE 5-28. PUMPING RATES AND EXPECTED TIME REQUIRED TO REACH TARGET CLEANUP LEVELS IN GROUNDWATER

Site	Pumping Rate (GPM)	Min. Time to Reach Target Cleanup Levels in Groundwater(1) (Years)	Max. Time to Reach Target Cleanup Levels in Groundwater(2) (Years)
IS-1	150	1.8	5.5
SP-5/5A(3)	-	-	-
SP-7/10	200	2.7	8.2
SP-15	40	2.3	7

(1) Based on probable site conditions, porosity = 0.25, removing 2 volumes of contaminated groundwater.

(2) Based on probable site conditions, porosity = 0.50, removing 3 volumes of contaminated groundwater.

(3) Since the source of contamination at Site SP-5/5A may be leaking tanks and piping, a pumping rate and time to cleanup cannot be determined until the source of contamination is eliminated.



NOT TO SCALE

DUAL PUMP PRODUCT
RECOVERY SCHEMATIC
ALTERNATIVE 3 & 6

IRP Stage 3 RI/FS Elmendorf AFB, AK	Figure 5-14

pumping rates and maintain the liquid level so that only pure product is withdrawn for recovery.

The discharge of the water table depression pump is routed to the treatment facility for removal of dissolved organics while the discharge from the fuel recovery pump is directed to an above ground storage tank sized to hold one weeks worth of accumulated product. The storage tank will be constructed in accordance with appropriate codes and standards for fire safety and placed in a containment structure to control the release of product in the event of a spill or overflow. A level control inside the storage tank will shut the entire recovery system off in the event that the tank becomes too full. In addition, all underground piping will be double wall constructed to contain leakage of product and all pumps in contact with fuel will have explosion proof motors. On a weekly basis, the contents of the fuel storage tank will be emptied and hauled offsite for recycling by DRMO. The fuel recovery process is capable of removing essentially all of the undissolved hydrocarbons from the groundwater surface.

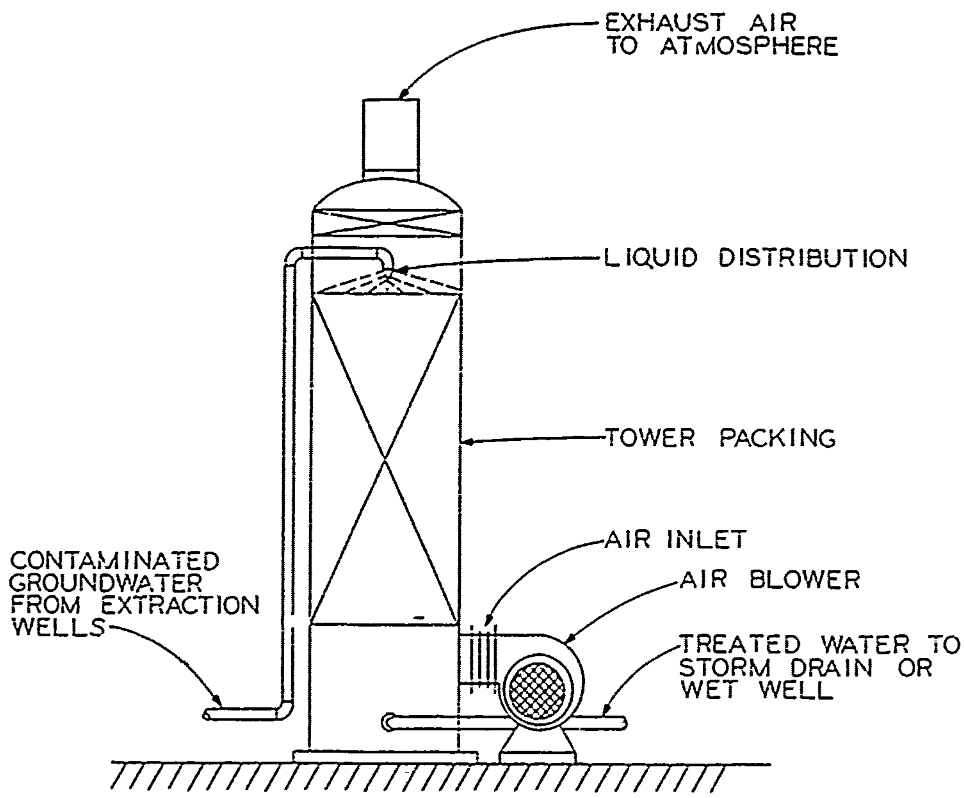
After fuel recovery the product recovery well will serve as an extraction well. The flows from the individual extraction wells are combined and routed to the air stripping tower. The air stripping unit is designed to remove the BETX compounds dissolved in groundwater to target cleanup levels. Air stripping is based on the principles of vapor-liquid equilibria. Contaminated groundwater is pumped to the top of a tall cylindrical column filled with internal packing to a minimum depth of 20 feet. The packing media causes the water to form tiny droplets as it falls downward through the column, thus increasing the surface area for air/liquid contact. At the same time, air is forced upward from the bottom of the packed bed and allowed to come in contact with the water droplets. The volatile organics are readily soluble in the gas phase and thus effectively stripped from the

liquid. The air stream carrying the volatilized organics is allowed to discharge from the top of the column, while treated water is discharged from the bottom.

The air-water partitioning coefficient for each BETX compound is favorable for removal by air stripping. Stripping performance is heavily dependant upon air and water temperatures, with efficiency decreasing at lower temperatures. However, modeling of the air stripping process using established mass transfer correlations adjusted for lower temperatures shows that target cleanup levels for BETX contaminants should be achievable without preheating water or air even during cold temperature extremes at Elmendorf AFB.

A diagram of the air stripping unit including the major equipment associated with the process is shown on Figure 5-15. Major components of the air stripping process include air blowers to force air upward through the column, discharge pumps and piping to transport treated liquid from the column, an outlet wet well for collection of treated water, a vertical column made of corrosion resistant material and internal packing to increase water surface area.

Specific information on flow capacities and equipment sizing will vary between individual sites. Appendix N provides preliminary design information on the air stripping process for cost estimating purposes. Vendor information is also provided in Appendix P. Some important variables which have a direct effect on air stripping performance and which are considered in detail during actual design are packing height, air-to-water ratio, water temperature and air temperature. Due to severe winter conditions, process equipment will have to be winterized for optimal performance during freezing conditions. Winterization of the air stripping process will include a building to house process equipment including pumps, blowers, and instrumentation. In addition, all exposed above ground piping will be insulated and



NOT TO SCALE

AIR STRIPPING
TREATMENT SCHEMATIC
ALTERNATIVE 3

IRP Stage 3 RI/FS
Elmendorf AFB, AK

Figure
5-15

heat traced to prevent freezing. Heated well houses will be placed over extraction and product recovery wells except at locations where height restrictions apply.

The proposed discharge of treated effluent is to Knik Arm via existing base storm drains as shown in Figures 5-9 through 5-12. The quality of effluent from the air stripper will meet or exceed target cleanup levels and state drinking water standards for TPH and volatile organics. Therefore, discharge in this manner should be acceptable. An NPDES permit will be required for direct discharge to surface waters. The conditions of the permit will determine the extent of monitoring and sampling required to verify compliance.

The State of Alaska has not established discharge requirements for off-gases leaving air stripping treatment units used for groundwater remediation. Therefore, it is not anticipated that secondary treatment to remove volatile organics from the discharge air stream will be a requirement. However, in the event that regulations change and off-gas treatment becomes necessary, technologies such as vapor phase carbon adsorption or catalytic combustion can be incorporated into the system.

The location of the treatment process at individual sites is shown on Figures 5-9 through 5-12. The figures also show proposed locations for new monitoring wells. In some cases it will be possible to utilize existing monitoring wells and these have also been identified on each figure. Installation of groundwater monitoring wells will be as described in Alternative 2. The purpose of monitoring on under this alternative is to assure that contaminated groundwater is adequately contained by the extraction system and also to monitor the progress of cleanup activities. Monitoring will continue until remediation at each of the sites is completed. In addition to groundwater monitoring, active drinking water wells will be monitored as described under Alternative 2.

Specific variations of the alternative to meet individual site conditions include the following:

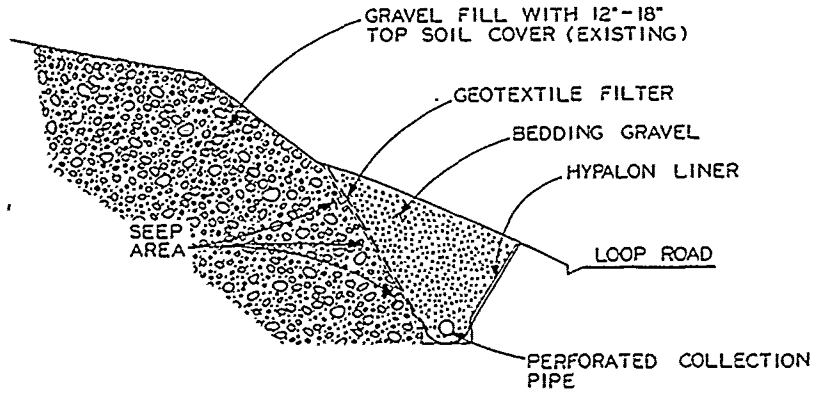
- o Site IS-1 - One product recovery well will be located next to monitoring well number W-18, where pure fuel product was observed in groundwater samples during the RI. Two new monitoring wells will be installed downgradient from the extraction system as shown in Figure 5-9. One new well will be installed near well W-18 and screened in the deeper portion of the aquifer. The 2 new downgradient monitoring wells together with existing well IS4-01 at Site IS-4 will be used to verify that the extraction system is properly capturing the contaminated plume. Well number W-18 and the new well next to it will be monitored to measure system cleanup performance. Existing monitoring wells IS1-01 and W-19 will be used to provide information on groundwater quality upgradient of the site.

- o Site SP-5/5A - This site will include an interceptor trench for the collection of groundwater. The purpose of the interceptor trench is to contain the active seep identified along the hill side just north of Loop Road at Site SP-5A. The trench also serves as a collection device for the seeping fuel/water mixture so that separation and treatment can follow. The system will be designed to handle a maximum seepage rate of 100 gpm, however, actual flow rates are estimated to be much lower. As shown in Figure 5-10, the trench will parallel Loop Road for 800 feet. The trench will be constructed to ensure contact with a minimum of 3 to 4 feet of the upper groundwater layer. Trench shoring will be required during excavation to prevent loose soil and gravel from filling the trench and injuring workers. The

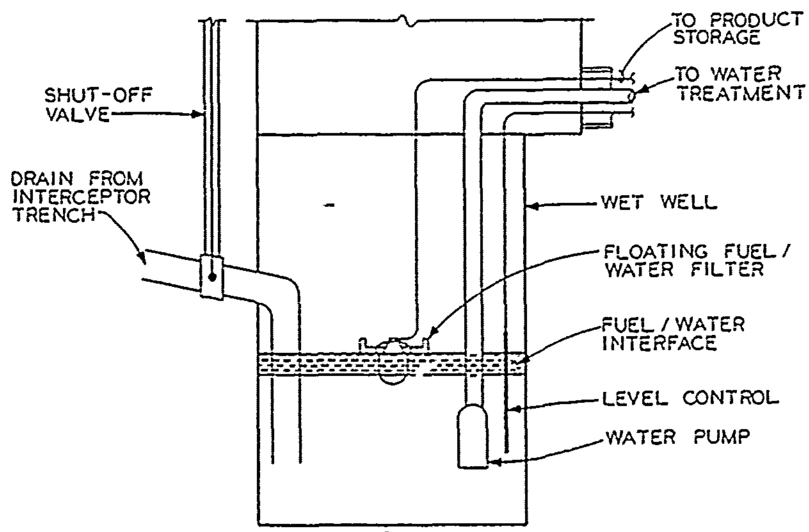
interceptor drain consists of a buried perforated pipe surrounded by a geotextile filter to prevent fines from clogging the system. A synthetic liner is placed on the bottom and the downgradient wall of the trench to prevent the percolation of contaminated water back into the soil. The upgradient wall of the trench will be lined with geotextile filter material, before backfilling the trench with gravel. A schematic of the interceptor trench and drain system is shown on Figure 5-16.

The trench will slope gradually toward an underground wet well designed to collect the drainage and serve as a fuel/water separator. As shown in Figure 5-16, the liquid level in the wet well is controlled by a submersible pump. Fuel is skimmed from the surface by a floating fuel/water filter. The pure product is discharged to an above ground collection tank and the water phase is pumped to the treatment process for removal of dissolved VOCs. The wet well and treatment system will be constructed prior to trench excavation in order to provide a means for treatment and discharge of accumulated liquids during the trench dewatering process. Excavated soils which are heavily contaminated with fuel will be transported offsite for disposal at any approved RCRA facility. After treatment, the effluent from Site SP-5/5A will be pumped through underground piping to Knik Arm for discharge. A storm drain system does not exist at the site and therefore the underground pipeline will have to be constructed as part of the remedial action.

In addition to the interceptor trench, a groundwater extraction well will be located near existing monitoring well SP5/5A-10 as shown on Figure SP5/5A-10. Benzene concentrations were detected at 28 ug/L in a sample



INTERCEPTOR TRENCH
SYSTEM SP-5/5A
NOT TO SCALE



FUEL RECOVERY
SYSTEM
NOT TO SCALE

COLLECTION SYSTEM
SCHEMATIC
ALTERNATIVES 3 & 6

IRP Stage 3 RI/FS Elmendorf AFB, AK	Figure 5-16

collected from well number SP5/5A-10 during the field investigation program indicating probable contaminant migration to the northwest in addition to the southeast.

Seven new monitoring wells will be installed at the site. Two will be installed northwest and downgradient from well SP5/5A-10 to assure that the plume migrating in that direction is effectively captured by the single extraction well. Existing well SP5/5A-20 will be used for the same purpose. Two new monitoring wells will be located southeast and downgradient from existing wells SP5/5A-16 and SP5/5A-19, and will be used to monitor and verify the performance of the trench in capturing contaminated groundwat in the seep area. One new well, located next to SP5/5A-16, will be completed in the deeper portion of the aquifer to delineate the vertical extent of contamination. Other wells will be located around the perimeter of the site, as shown on Figure 5-10. Wells SP5/5A-16 and SP5/5A-19 exhibited some of the highest BETX contamination during the field investigation. Existing wells SP5/5A-01, 06, 15, 16, 18 and 19 will continue to be monitored in order to measure increases or reductions in contaminant levels at the site.

Site SP-5/5A was evaluated for interim remedial measures in the Draft Report: Expedited Results and Recommended Interim Remedial Measures Site SP-5/5A (Black & Veatch, 1988). As part of the remedial action, the report recommends that underground storage tanks, pipes, and appurtenances be inspected to determine the following:

1. Whether leakage from underground tanks, pipes, and appurtenances are the cause of contamination.
2. Whether past spills (releases) and therefore heavily contaminated soils are the only cause of contamination.
3. Or whether contamination is caused by a combination of 1 and 2 above.

Leak detection, corrosion protection, and spill/overfill prevention of underground storage tanks and piping is required under 40 CFR 280 and 281. EPA published the final rule on the management of and corrective action for Underground Storage Tanks (USTs) in the September 23, 1988 Federal Register. The rule became effective on December 22, 1988. However, these tanks are deferred from the majority of the UST regulations, since they are part of an airport hydrant fuel system. The system is subject to the release response correction action regulations. Minimum UST requirements are presented in Appendix O. Although not required, leak detection should be implemented at this site to determine if there is ongoing contaminant source. Three choices for implementing a leak detection program for existing tanks are also presented in the appendix. The leak detection program for Site SP-5/5A should be expedited so that results of the monthly monitoring or monthly inventory control and annual tank tightness testing can be used to determine if the tanks and/or piping are leaking and are a source of contamination.

o Site SP-7/10 - Height restrictions apply in areas near the base runways. The restrictions will require that the air stripping tower at Site SP-7/10 be moved a minimum of 1,200 feet from the centerline of the runway. The proposed location of the treatment system is shown on Figure 5-11. A product recovery system will be located near building 42-103, where pure fuel product was observed in groundwater samples during the RI. Another extraction well will be located downgradient and in the probable path of contaminant migration near existing monitoring well number W-4. Three new monitoring wells will be installed to the south and southeast of the extraction well to assure that the system is effectively capturing all of the plume. Existing monitoring well SP7/10-01 will be used for the same purpose. Existing monitoring wells W-4 and SP7/10-04 will be utilized

to measure the progress of the extraction system in reducing contaminant levels in groundwater. A new well will be installed next to SP7/10-04 and completed in the deeper portion of the aquifer to delineate the vertical extent of contamination. Existing monitoring wells SP7/10-02 and SP7/10-03 will provide information on groundwater upgradient of the site.

- Site SP-15 - One extraction well will be installed southwest from existing monitoring well SP7/10-01. This was the only well which showed evidence of contaminated groundwater at the site. Two new monitoring wells will be installed downgradient of the extraction system at locations shown on Figure 5-12 to assure plume capture. Existing monitoring well SP7/10-01 will be used to monitor cleanup performance. A new well will be installed next to SP15-01 and completed in the deeper portion of the aquifer to assess the vertical extent of contamination. Existing monitoring well number SP7/10-02 will be used to provide information on groundwater quality upgradient of the site.

Alternative 3 is applicable to sites IS-1, SP-5/5A, SP-7/10, and SP-15.

5.4.4 Alternative 6 - Collection, Onsite UV/Oxidation, Surface Discharge (Groundwater)

In this alternative, collection, pretreatment, surface discharge, and monitoring are the same as described in Alternative 3. Treatment of the organic compounds dissolved in the groundwater is accomplished by a destruction process utilizing ozone gas, hydrogen peroxide liquid, and ultraviolet (UV) light. The pretreated liquid is pumped to a reaction vessel where ozone and hydrogen peroxide are added. Under the UV light, ozone and hydrogen peroxide form hydroxyl radicals which react with and destroy organic compounds by photochemical oxidation. A process flow diagram of the system is shown on Figure 5-17 and 5-18.

The major components of the system include the following:

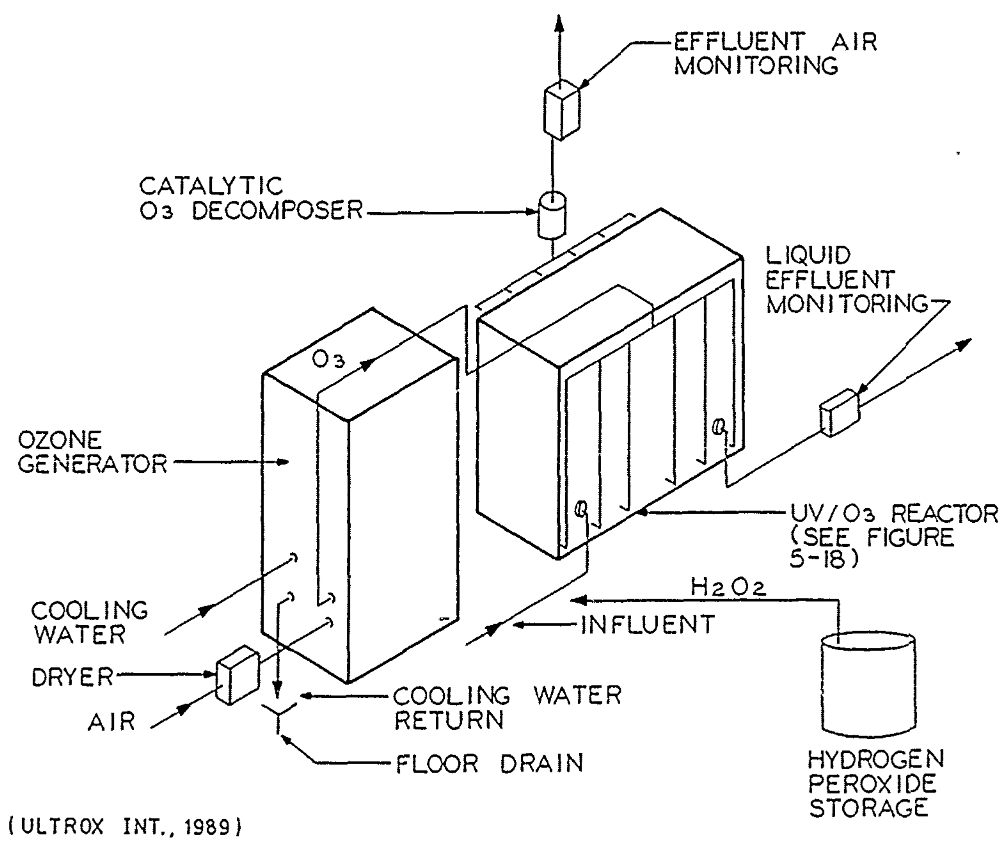
- Ozone Generator - An onsite generator is used to produce ozone for the reaction. Ozone is produced by high voltage ionization of atmospheric oxygen. Ozone gas enters the reaction vessel through diffusers.

- Ozone Decomposer Unit - Unreacted ozone is converted back to oxygen by catalytic reaction. Ozone in the off-gas is reduced to acceptable air quality standards. The system is also equipped with a sensor and alarm to detect and warn against ozone escaping from the system.

- Hydrogen Peroxide - Hydrogen peroxide is stored in an enclosed process tank and injected into the system at the established optimum rate. The tank is isolated and contained to prevent spillage or reaction of hydrogen peroxide with other materials. In addition, a bulk storage tank is required for the hydrogen peroxide. The nearest supplier of hydrogen peroxide is located in Vancouver, British Columbia.

- Reaction Vessel - The reactants are contacted with the wastewater in a stainless steel reactor. The volume of the reactor is determined by the optimum retention time required to destroy the contaminants of concern. The UV lamps are also housed within the reactor.

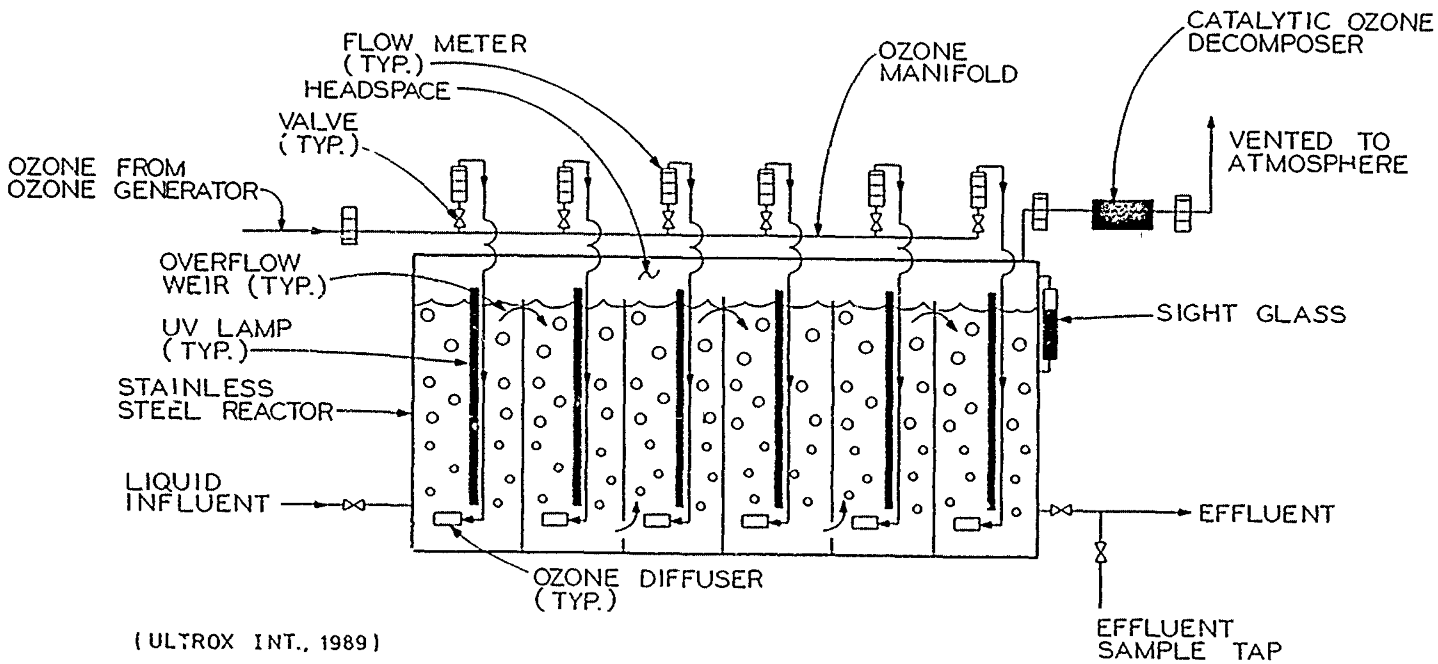
- General Process Equipment - Process equipment includes chemical feed pumps, controls, piping, and instrumentation. All major equipment in contact with liquids will be constructed of stainless steel.



UV/OXIDATION
FLOW SCHEMATIC
ALTERNATIVE 6

IRP Stage 3 RI/FS
Elmendorf AFB, AK

Figure 5-17



INTERNAL VIEW OF UV/OXIDATION REACTOR ALTERNATIVE 6

IRP Stage 3 RI/FS
Elmendorf AFB, AK

Figure 5-18

Vendor information is provided in Appendix P.

The advantage of this process over other alternatives is that essentially complete conversion of the toxic organic contaminants to carbon dioxide and water can be achieved. Under normal operating conditions, the liquid effluent may contain trace quantities of organic acids, which remain as reaction intermediates, and unreacted hydrogen peroxide. Off-gases from the reactor pass through an ozone decomposer unit which reduces ozone levels to acceptable air quality standards. The off-gases will also contain some volatile organics which are inadvertently stripped from the solution during reaction. The volatilized compounds will be vented from the system and discharged to the atmosphere along with the treated ozone.

The primary disadvantage with UV/Oxidation is that it has not been used extensively in the field. The process has, however, demonstrated successful cleanup of BETX contaminants with the same relative concentration at other sites involving fuel contamination of groundwater. UV/Oxidation is currently being tested under the EPA Superfund Innovative Technology Evaluation (SITE) Program. Because of the lack of site experience and the amount of chemistry involved with the process, treatability studies with a pilot scale unit will be required before detailed design of the final system. The cost of treatability testing has been accounted for in the total capital cost of this alternative. Other factors which affect process performance and which will be evaluated in detail during treatability testing include water temperature, concentration of total suspended solids and total organic carbon, retention time in the reactor, and reactant dosages to provide optimum and selective conversion of organic contaminants. Previous studies have shown that a 1:1 ratio of ozone to hydrogen peroxide can provide greater than 99.9 percent removal of benzene and 99.9 percent removal of total BETX compounds. Pilot plant testing will also provide detailed information on the level of water quality obtainable for final discharge.

All process equipment will be located inside a building with adequate ventilation. The system will require periodic attention by an operator to inspect the system, fill process tanks, and make any necessary adjustments to process flows or reactant addition rates. The operator will also sample and monitor the treated effluent as required by the NPDES permit.

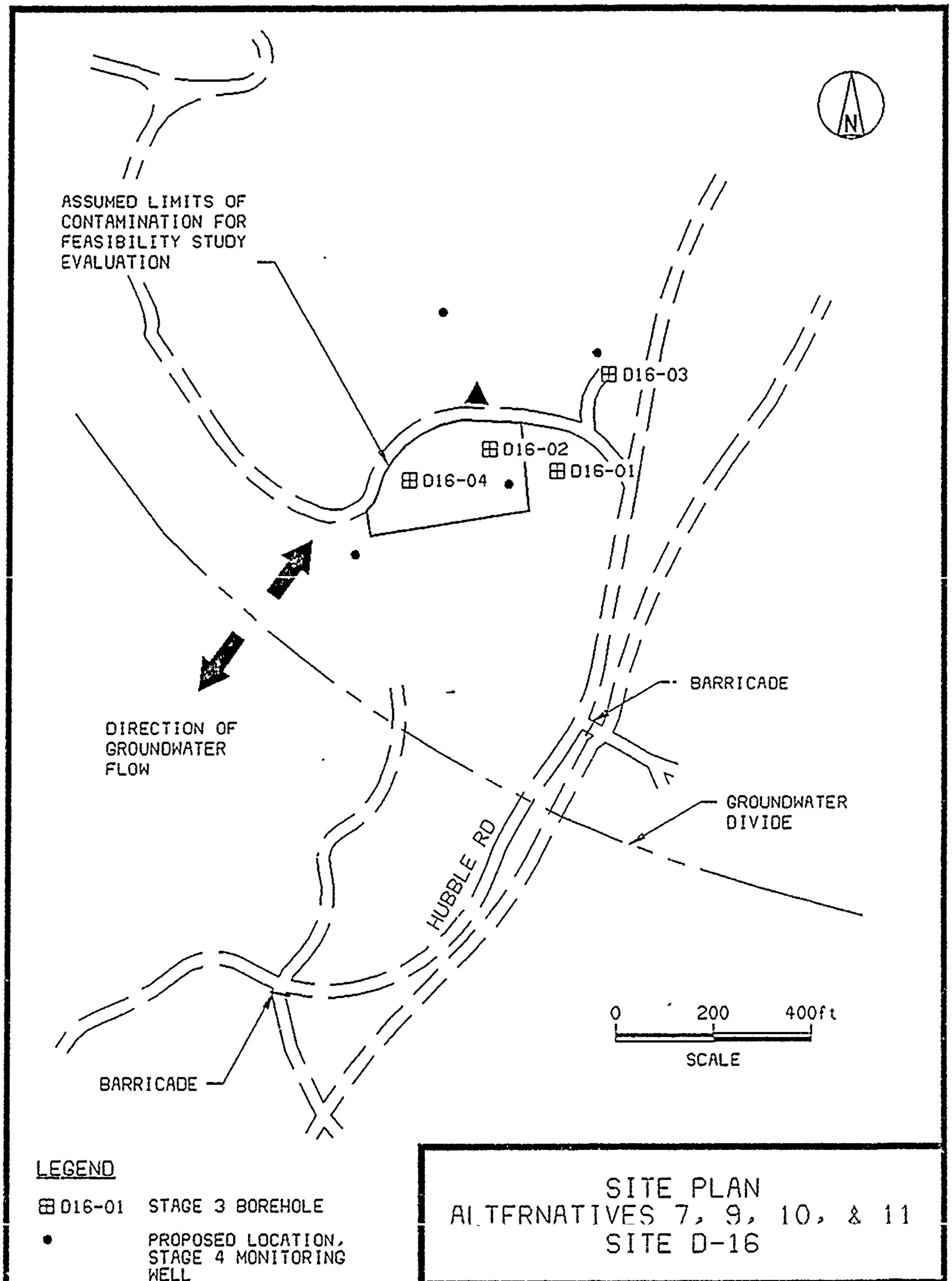
This alternative is applicable to Sites IS-1, SP-5/5A, SP-7/10, and SP-15. The location of the treatment building, monitoring, and extraction wells at each site will be the same as described for Alternative 3 and are shown on Figures 5-9 through 5-12.

5.4.5 Alternative 7 - <u>Containment by Surface Capping (Soil)</u>

This alternative utilizes soil capping technology to prevent contact with and minimize migration of contaminants. The surface of the contaminated area is capped with a soil-synthetic membrane cover to eliminate direct human exposure to surface soils and prevent the infiltration of precipitation and subsequent leaching of contaminants from the soils. The alternative also includes site security fencing and groundwater monitoring.

The field investigation program indicated that 2 boring locations at Site D-16 are contaminated by TPH at depths of up to 5 feet. Boreholes D16-01 and D15-03 did not exhibit elevated levels of TPH. Figure 5-19 shows the areal extent of soil contamination as defined by the most probable site conditions in Section 5.2.3, Table 5-9. Based on current information, it appears that the area is approximately 1.5 acres. The assumed average depth of contamination is 6 feet, resulting in a total volume of 15,000 cubic yards of contaminated soil.

Under this alternative a multilayer cap will be installed over the contaminated area in the following manner. After the site has been



SITE PLAN
ALTERNATIVES 7, 9, 10, & 11
SITE D-16

IRP Stage 3 RI/FS
Elmendorf AFB, AK

Figure 5-19

cleaned and grubbed a 2-foot layer of clay from the Bootlegger Cove Formation will be placed over the contaminated soil followed by a synthetic membrane at least 30 mils thick, a 1 foot sand drainage layer, a geotextile layer, 1.5 feet of native soil, and 6 inches of vegetated topsoil. The surface layer of the cap will be sloped a minimum of 2 percent to enhance runoff during precipitation events. Drainage channels will be incorporated to handle runoff from precipitation.

In conjunction with the capping system, a total of 4 monitoring wells and 1 new soil boring will be installed. Two of the wells will be placed 200 feet downgradient (north and northeast) of the site; 1 approximately 200 feet upgradient (southwest) of the site; and 1 near the location boring D16-02. This well will be screened in both the upper and lower portions of the aquifer to assess the extent of vertical contamination. The wells will be installed following the same methods described in Section 5.4.2 under Alternative 2. However, the estimated total depth of the wells at Site D-16 will be 50 to 70 feet based on regional groundwater patterns. The purpose of groundwater monitoring under this alternative is to first establish whether or not groundwater has been contaminated at the site and second to verify that contaminants are not migrating offsite via groundwater mechanisms during the life of the cap.

Restrictions on the use and development of the site will be required because contaminants are left at the site and to ensure the integrity of the multilayer cap. These restrictions will preclude further use of the site. Installation of the multilayer cap and the site security fencing will be effective in eliminating the potential for direct contact with, or ingestion of, onsite contaminants and will preclude the transport of these contaminants to offsite areas via surface water or airborne transport mechanisms. In the event that groundwater is contaminated, the reduced volume of infiltration will reduce the

hydraulic driving force that moves the contaminated groundwater towards offsite areas.

This alternative is applicable to Site D-16.

5.4.6 Alternative 9 - Excavation and Disposal in a Sanitary Landfill (Soil, Site D-16)

This alternative consists of the excavation and removal of soils at Site D-16 and disposal at the Anchorage Regional Landfill facility which accepts soils containing TPH concentrations of less than 1000 ppm. Standard landfill operating equipment, such as, bulldozers, backhoes, and dump trucks will be used to remove contaminated soil and transport it to the local landfill. The 3 concrete slabs on the site will be decontaminated, broken apart and transported to the landfill. All remaining fuel filters and pads will also be transported and disposed of with the soils. The Regional Landfill is contained with a high density polyethylene (HDPE) liner and is equiped with a leachate collection system and groundwater monitoring system.

As discussed in the previous alternative, soil contamination has only been documented in two borings to a depth of 5 feet. Based on this information, it appears that an area of 1.5 acres will need to be excavated to a minimum depth of 6 feet, or a total of 15,000 cubic yards. HNU (or other organic vapor analyzing devices) readings will be used as a guide for determining the limits of excavation dimensions. When sufficiently low HNU readings are obtained, soil samples will be collected and analyzed. This procedure will continue until TPH levels are less than 100 ppm throughout the site. Local borrow material will then be imported to backfill the excavation and complete the site remediation.

The Anchorage Regional Landfill cannot accept hazardous wastes. Soils at Site D-16 were analyzed only for TPH, lead, and total solids during

the RI. Since past disposal practices at the site have involved petroleum products, a complete soil analysis of total petroleum hydrocarbons and volatile organic compounds will be required before disposal can be permitted in the landfill. Specific landfill requirements are listed in Appendix Q. If average TPH concentrations are above 1000 ppm or if VOCs are sufficiently high to designate the soil a hazardous waste, a RCRA-permitted landfill as described in Alternative 10 will be required for disposal.

In conjunction with soil excavation and removal, three monitoring wells will be installed as described in Section 5.4.5 for Alternative 7.

Offsite disposal of contaminated soils allows for unrestricted future use of the site and will be effective in eliminating the potential for direct contact or ingestion of contaminants. The potential for offsite transport of these contaminants via groundwater, surface water, or airborne transport mechanisms will also be eliminated.

5.4.7 Alternative 10 - Excavation and Disposal in a RCRA-Permitted Landfill (Soil, Site D-16)

Alternative 10 is essentially the same as Alternative 9 except that excavated wastes will be hauled to a RCRA-permitted facility for treatment and/or disposal if further sampling and analysis indicate that the soil should be classified as a hazardous waste or will not meet the regional landfill requirements. If average TPH levels are greater than 1000 ppm, or other volatile organic compounds are identified at significant levels as determined by the ADEC, it will be necessary to dispose soil as a hazardous waste. The State of Alaska does not have a RCRA-permitted facility; therefore, soils will be hauled to an out-of-state facility.

As with Alternative 9, offsite disposal of contaminated soils will allow for unrestricted future use of the site and will eliminate the potential for direct contact or ingestion of contaminants. The potential for offsite transport of these contaminants via groundwater, surface water, or air transport mechanisms will be eliminated. Groundwater monitoring will also be implemented, as in Alternative 7 to determine whether groundwater has been contaminated at the site and to ensure that successful removal of contaminated materials has been accomplished.

5.5 EVALUATION OF DETAILED ALTERNATIVES (FS PHASE III)

This section provides a detailed evaluation of the alternatives developed in Section 5.4 In accordance with USAFOEHL/TS's Handbook to Support the IRP Statements of Work for RI/FS, the alternatives are evaluated in terms of the following 5 categories which are discussed in Sections 5.5.1 through 5.5.5:

- o Technical Feasibility.
- o Environmental Impacts.
- o Public Health Impacts.
- o Institutional Requirements.
- o Cost Analysis.

Nine evaluation criteria are presented in the March 1988 Draft EPA Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA. These evaluation criteria are:

- o Short-term effectiveness.
- o Long-term effectiveness and permanence.
- o Reduction of toxicity, mobility, or volume.
- o Implementability.
- o Cost.
- o Compliance with ARARs.
- o Overall protection of human health and the environment.
- o State acceptance.
- o Community acceptance.

The nine evaluation criteria from the CERCLA RI/FS guidance document have been incorporated into the 5 categories presented in the USAFOEHL/TS Handbook. A final list of criteria which combines the requirements of the USAFOEHL/TS and CERCLA guidance are presented in Table 5-29.

In this section, each alternative is discussed and evaluated based on the criteria listed in Table 5-29. The technical evaluation addresses

TABLE 5-29. DETAILED EVALUATION CRITERIA

Technical Analysis

- o Performance
  - Effectiveness
  - Useful Life
- o Reliability
  - Operation and Maintenance Requirements
  - Demonstrated Performance
- o Implementability
  - Constructability
  - Time to Implement/Time to Reach Remedial Action Objectives
  - Availability of Offsite TSD Facilities
  - Ability to Monitor Effectiveness of Remedy
- o Safety
  - Worker
  - Neighborhood

Institutional Requirements

- o Conformance to ARARs
- o Permitting Requirements
- o Community Concerns
- o State Acceptance

Environmental Impacts

- o Beneficial Effects
  - Final Environmental Conditions
  - Improvements in Biological Community
  - Improvements in Human Use Resources
- o Adverse Effects
  - Construction and Operation
  - Mitigative Measures

TABLE 5-29 (Continued). DETAILED EVALUATION CRITERIA

- o Public Health Impacts

    - Risk Assessment
    - Minimization of Chemical Releases
    - Exposures during Remedial Action
    - Exposures after Remedial Action

- o Cost

    - Capital Cost
    - Operation and Maintenance Costs
    - Present Worth

the technical feasibility of the alternatives based on performance, reliability, implementability, and safety. The environmental impacts of each alternative are evaluated by comparing beneficial and adverse effects to the no action alternative. Each alternative is then evaluated on its ability to limit long-term exposure to contamination and avoid unacceptable threats to public health both during and after completion of the remedial action. The institutional requirements evaluation addresses the alternative's conformance with ARARs, permitting requirements, and state acceptance as well as community concerns. The cost analysis includes the capital cost to implement each alternative and operation and maintenance costs on a per year basis for the duration of remediation. The present worth of each alternative is also presented to compare the alternatives.

The results of the detailed evaluation for each alternative will be rated with respect to each of the criteria listed in Table 5-29. The rating system terms will be expressed as high, moderate, and low. In general:

- A high rating indicates that the alternative promotes the intent of the criteria and/or meets or exceeds the remedial objectives.

- A moderate rating indicates that the alternative only partially promotes the intent of the criteria, however, the alternative does remediate the problem to an appreciable extent even though it may not meet all the remedial objectives.

- A low rating indicates that the alternative does not promote the criteria and/or does not meet the remedial objectives.

The remedial objectives for protection of human health and the environment were defined in Section 5.2.1. The specific goals for remedial action at sites D-16, IS-1, SP-5/5A, SP-7/10 and SP-15 are as follows:

- o Prevent ingestion of and contact with groundwater or soil having concentration levels in excess of target cleanup levels.

- o Prevent further migration of soil and groundwater contaminants to other media or receptors.

- o Improve soil and groundwater quality to target cleanup levels.

At the beginning of each subsection, the above ratings will be specified relative to the criteria being rated. The ratings are then combined to form an overall category rating for each of the alternatives. In the event that there is not a clear category rating, subjective weighting will be used to assign an overall rating.

The detailed analysis of alternatives is not intended to be all inclusive, but is intended to present sufficient information on each alternative to allow a comparative evaluation of the alternatives. Additional information will be required during the design of the selected alternative.

5.5.1 Technical Analysis

This section presents a technical evaluation of alternatives in terms of performance, reliability, implementability, and safety.

The performance of each alternative was based on the alternative's expected effectiveness and useful life. The effectiveness evaluation

addresses the suitability of the measure to meet the remedial action objectives. It also addresses the degree to which an action will prevent or minimize substantial danger to public health, welfare, or the environment. The effectiveness of an alternative also is a function of how well components of the alternative can be integrated to provide an overall solution. Effectiveness is evaluated on the following scale:

- o High - Minimizes further migration of contaminants; adequately protects human health and environment.

- o Moderate - Controls migration of contaminants; adequately protects human health and environment.

- o Low - Allows migration of contaminants; does not protect human health and environment.

The useful life of a remedial measure is the length of time this level of effectiveness can be maintained without consideration for replacement, with appropriate operation and maintenance procedures. Useful life is evaluated on the following scale:

- o High - All technologies and all remedial actions are permanent and require no major maintenance or replacement.

- o Moderate - Overall long term solution requiring only routine maintenance and/or replacement.

- o Low - Short-term solution requiring frequent extensive maintenance; repair impractical upon failure.

Reliability is evaluated in terms of operation and maintenance requirements, and demonstrated performance at sites similar in nature.

Operation and maintenance requirements include availability of labor and materials, and the frequency and level of difficulty associated with operation and maintenance activities, such as patching cracks in surface caps. Technologies which require frequent repairs, as often as once a month, or that are complex to maintain and operate, are considered less reliable. Evaluation of demonstrated performance includes an estimation on probability of breakdown for each component of the system and the applicability and performance of the technologies demonstrated at similar sites. When assessing reliability, field tested methods are given preference over technologies that have not been applied to actual site cleanup operations. O&M requirements are evaluated on the following scale:

- High - Requires infrequent attention; capable of functioning unattended with periodic maintenance.

- Moderate - Capable of functioning unattended but requires more frequent attention.

- Low - Requires very frequent or constant attention by full-time trained personnel.

Demonstrated performance is evaluated on the following scale:

- High - All remedial technologies proven reliable in the field under similar conditions on similar waste materials.

- Moderate - Proven reliable but under different conditions or with different waste materials.

- Low - Demonstrated only in laboratory or pilot scale; not fully demonstrated for practical field conditions.

Implementability addresses the constructability or ease of installation and the availability of necessary offsite facilities, the time required to implement the alternative, and the time required to achieve a given level of response. Constructability considers whether the alternative can be constructed on the site and the impact of external conditions on the construction of the alternative, such as the ease of acquiring access, zoning clearances, and local permits. The time it takes to implement an alternative includes allowance for special studies, design and construction. Time to achieve beneficial effects spans from the end of construction to the time when the level of contamination has been reduced to meet applicable or relevant and appropriate requirements. The availability of necessary offsite facilities refers to treatment, storage, and disposal facilities, their locations, and types of acceptable wastes.

Constructability is evaluated on the following scale:

- High - Routine construction effort.
- Moderate - Difficult to construct due to site restrictions, difficulty in obtaining building permits, or lack of necessary offsite facilities.
- Low - Magnitude of construction effort is excessive, difficult to acquire building permits, lack of necessary offsite facilities.

Time to implement the remedial alternative is evaluated on the the following scale:

- High - Alternative can be implemented in less than 6 months.
- Moderate - Alternative can be implemented in 1 to 2 years.

o Low - Alternative requires more than 3 years to implement.

Time to achieve beneficial results is evaluated on the following scale:

- o High - Immediate overall results (within implementation period).
- c Moderate - Timely overall results but requires between 1 and 10 years.
- o Low - Obtaining overall results requires greater than 10 years.

The safety criteria considers short-term and long-term threats to safety of nearby residents as well as to persons working on the site. Major risks to consider are exposure to hazardous substances, fire, and explosion due to activities conducted during implementation of the remedial action. Short-term and long-term safety aspects of the remedial action as they pertain to both workers onsite and to the surrounding populace are evaluated on the following scale:

- o High - Remedial actions are relatively safe; requires few safety procedures other than those normally required at hazardous waste sites; little or no threat to workers or surroundings.
- o Moderate - Requires constant monitoring and stringent safety procedures; potential threat to workers and surroundings.
- o Low - Very hazardous, requires remote operation and evacuation of area homes.

A summary of the technical analysis evaluation is presented at the end of this section in Table 5-30.

5.5.1.1 Alternative 1 - No Action

A technical evaluation of the no action alternative is inappropriate because there is no technology proposed for use. Therefore, the performance, reliability, implementability, and safety aspects of the alternative are not applicable.

5.5.1.2 Alternative 2 - Groundwater Monitoring, Groundwater Use Restrictions, Alternate Water Supply

This alternative involves long term monitoring to detect contaminants migrating in the direction of water supply wells, quarterly monitoring of active drinking water wells for VOCs and groundwater use restrictions in the event that water supplies are found to be contaminated.

5.5.1.2.1 Performance

Monitoring of groundwater will not minimize the migration of contaminated materials. It also will not reduce the toxicity of contaminants. Monitoring, however, will be an effective indicator of potential health risks associated with ingestion of contaminated water supplies. It is anticipated that only routine maintenance and sampling of base wells and monitoring wells will be necessary.

The monitoring wells will be used to track the migration of contaminants from each site. The wells installed under this alternative, in conjunction with existing monitoring wells, will provide data to assess potential impacts on drinking water sources. This alternative meets 1 of the 3 objectives for remedial action

in that it minimizes the potential for human ingestion of contaminated groundwater. However, contaminants are not reduced or removed and no previsions are made for control of migration. The effectiveness rating is therefore low to moderate. The monitoring system will require only routine operation and maintenance and therefore the useful life is rated high.

5.5.1.2.2 Reliability

Monitoring wells are designed to operate with a minimum of maintenance. Inspection of the monitoring well during the scheduled sampling event as well as periodic maintenance may be required. Normal maintenance of base supply wells and associated pumps is also anticipated. The use of groundwater monitoring is a well established and proven reliable technology for the detection of contaminated groundwater. The methodology for the analysis of water samples for VOCs (EPA method 624) is well established and widely used. Quality assurance/quality control checks will be incorporated in the sampling and analysis procedures to increase the reliability of the analysis.

In evaluating the reliability of Alternative 2, the operations and maintenance rating is high and the demonstrated performance rating is high.

5.5.1.2.3 Implementability

Site conditions may affect the constructibility of this alternative. Locations of monitoring wells will be dictated by current locations of base features such as runways and hangers. Monitoring wells close to the runway will be installed flush with the ground in compliance with Air Force requirements. Other constraints on constructibility are related to severe weather conditions.

The time to implement this alternative is approximately 1 year, depending on weather conditions and availability of contractors, equipment and materials. Implementation will involve design report preparation and review. Installation of new monitoring wells, preparation of a sampling plan, and initiation of sampling. The time to reach desired results is immediate upon implementation of this alternative.

In evaluating the implementability of Alternative 2, the constructibility rating is moderate and the time to implement is also moderate. Alternative 2 does not reduce contamination, therefore, the time to reach beneficial results rating is low.

5.5.1.2.4 Safety

During installation of monitoring wells, workers may be exposed to contaminants in the soil and groundwater. Workers will follow all applicable OSHA guidelines for work on hazardous waste sites, wear personal protective equipment as required, and monitor ambient air quality to avoid exposure to contaminants and explosive gases. The surrounding community should not be exposed to contaminants during the installation of the monitoring wells.

During the implementation state of this alternative the surrounding community will not be exposed to contaminants. In the event that contaminants are identified in drinking water, groundwater use restrictions will be implemented.

In evaluating the safety of Alternative 2, the short-term and long-term safety ratings are high.

5.5.1.3 Alternative 3 - Collection, Onsite Air Stripping, Surface Discharge

The primary elements of this alternative include collection and containment of the groundwater plume by pumping from extraction wells, pretreatment to remove free floating fuel product, treatment of the groundwater by onsite air stripping, discharge of the treated effluent to local storm drains, and monitoring of groundwater to determine plume migration and cleanup performance.

5.5.1.3.1 Performance

The groundwater extraction well system will effectively remove contaminated groundwater migrating from areas of fuel spills to the approximate boundary of groundwater pumping influence. The interceptor trench system at Site SP-5/5A will effectively contain and control the fuel seep area. Areas downgradient of the extraction systems will benefit from lower concentrations of contaminants; however, contaminants may not be completely removed from the aquifer. The fuel/water separator and air stripping process will effectively treat contaminated groundwater to target cleanup levels before the groundwater is discharged to surface waters. This remedial action provides a long-term solution requiring only routine maintenance.

This alternative meets the objectives of the remedial action in that it reduces further migration of hazardous contaminants, provides a method to cleanup contaminated groundwater, prevents human exposure to contaminants, and provides a long-term solution that requires only routine maintenance. The effectiveness rating is high and the useful life rating is high.

5.5.1.3.2 Reliability

The groundwater extraction well system is designed to operate reliably with a minimum amount of maintenance. The design of the well head

allows for easy removal and servicing of pumps when necessary. Other routine maintenance such as repainting of guard posts around wells and servicing of well protection devices will also be performed on a yearly basis. The use of groundwater extraction wells as a means of removing contaminated groundwater is a well established and proven technology for the removal of contaminated groundwater. The dual pump product recovery system will have operation and maintenance requirements similar to those described for the extraction system. The dual pump system is considered a conventional technology for the removal of fuel product from groundwater. The interceptor trench and collection system at Site SP-5/5A will require low operation and maintenance. This type of collection system has been used successfully at numerous sites under similar conditions. Fuel storage tanks for the collection of separated product will require emptying on a weekly basis.

The reliability of groundwater monitoring in this alternative will be the same as described under Alternative 2.

Air stripping towers are also designed to operate reliably with a minimum amount of operation and maintenance. Maintenance of air stripping tower will include yearly inspection of blowers and pumps and acid/base treatment of the inside of the tower to remove any buildup or biological growth. The use of air stripping towers for the removal of BETX compounds from groundwater under similar site conditions is a well established and proven technology.

In evaluating the reliability of Alternative 3, the operations and maintenance rating is moderate and the demonstrated performance rating is high.

5.5.1.3.3 Implementability

Site conditions will affect the constructability of this alternative. Locations of the extraction wells, fuel storage tank, and air

stripping towers will be dictated by the current locations of base features such as runways and hangers. Implementability of the groundwater monitoring system will be the same as described under Alternative 2. As mentioned during the detailed description of Alternative 3 in Section 5.4.3 height restrictions apply in areas near the Base runways and therefore the air stripping tower at Site SP-7/10 will be located a minimum of 1,200 feet from the centerline of the runway. Other constraints on constructability are related to severe weather. Construction will be difficult during cold winter months at Elmendorf AFB.

As discussed in Section 5.4.3, the interceptor trench at Site SP-5/5A will require excavation and disposal of contaminated soils in an approved RCRA landfill. Since there are currently no such facilities in Alaska which can accept hazardous waste, transport of the soils out of state will be required. An NPDES permit will be required for direct discharge of treated waters into Knik Arm.

The time to implement this alternative will take approximately 1 to 2 years, depending on weather conditions and availability of contractors, equipment and materials. Implementation will involve design report preparation and review, preparation of drawings and specifications, construction and startup. The time to cleanup the groundwater to reach ARARs is 3 to 7 years, based on the most probable site conditions described in Section 5.2.3.

In evaluating the implementability of Alternative 3, the constructability rating is moderate, the time to implement is moderate, and the time to achieve desired results is also moderate.

5.5.1.3.4 Safety

During installation of extraction wells, monitoring wells and the interceptor trench at SP-5/5A, workers may be exposed to elevated

levels of contaminants in soil or groundwater. Workers will follow all applicable OSHA guidelines for work on hazardous waste sites, wear personal protective clothing as required, and monitor ambient air quality to avoid exposure to contaminants and explosive gases. The surrounding community will not be exposed to any elevated levels of contaminants during implementation.

During the construction of air stripping towers, neither workers nor the surrounding community should be exposed to contaminants unless contaminant concentrations increase dramatically over what was seen in the RI. Operation of air stripping towers results in air emissions having low contaminant concentrations and therefore neither the workers nor the surrounding community should be adversely affected by contaminants, again this is based on concentrations of contaminants identified in the RI. Both the short-term and the long-term safety ratings for Alternative 3 are high.

5.5.1.4 Alternative 6 - Collection, Onsite UV/Oxidation, Surface Discharge

Groundwater in this alternative is collected, treated, and discharged to surface water in the same manner as described under Alternative 3. Organic compounds are destroyed by a process that combines the strong oxidizing agents ozone and hydrogen peroxide to break down the contaminants of concern. Additional energy for the reaction is supplied by UV light. As with Alternative 3, groundwater monitoring will be incorporated to track the migration of the contaminant plume and provide updated information on cleanup performance.

5.5.1.4.1 Performance

The proposed onsite UV/Oxidation treatment system can effectively remove organic contaminants in the groundwater to meet target cleanup levels. This remedial alternative results in almost complete conversion of organic contaminants into carbon dioxide and water. Off-gases from the reaction are passed through a catalytic ozone decomposer unit which reduces ozone levels to acceptable air quality standards.

This alternative meets the remedial action objectives and provides a long-term solution which requires only routine maintenance. The effectiveness rating is high and the useful life rating is high.

5.5.1.4.2 Reliability

UV/Oxidation treatment equipment is designed to be fully automatic, it can be operated in either a continuous flow or batch mode. The system will require the attention of an operator for approximately 1 hour each day to inspect the system, fill process tanks, and make any necessary adjustments to process flows or reactant addition rates. UV lamps require replacement after 7800 hours of use, typically once a year. The ozone generator dielectric cells require cleaning once every 2 years. The compressor calls for normal, routine maintenance. Although UV/Oxidation has demonstrated successful cleanup of BETX contaminants under similar concentrations, the process is relatively new to groundwater remediation and has not been field tested nearly as extensively as air stripping. UV/Oxidation is currently being tested under the EPA SITE program. Under this alternative, the reliability of the collection and monitoring system is the same as described under Alternative 3 for air stripping.

In evaluating the reliability of Alternative 6, the operations and maintenance rating is low to moderate and the demonstrated performance rating is low.

5.5.1.4.3 Implementability

The same factors which influence implementability in Alternative 3 also affect implementability in this alternative with the exception of tower height restrictions. As described in Section 5.4.4, a treatability and pilot test will be required before design of this alternative. These studies could take up to 6 months for completion.

In evaluating the implementability of Alternative 6, the constructability rating is moderate, the time to implement rating is moderate, and the time to achieve desired results is also moderate.

5.5.1.4.4 Safety

All aspects of the safety evaluation as described for Alternative 3 in Section 5.5.1.3.4 also apply to this alternative except those references to the air stripping tower. Exposure to ozone gas is unlikely since the gas is contained within the reaction vessel and ambient air in the surrounding area is constantly monitored for ozone releases. The hydrogen peroxide storage tank is isolated and contained to prevent spillage or reaction with other materials. Both the short-term and long-term safety ratings are high.

5.5.1.5 Alternative 7 - Containment by Surface Capping

This alternative utilizes soil capping technology to prevent contact with and minimize migration of contaminants. The surface of the contaminated area is capped with a soil-synthetic membrane to eliminate direct human exposure to surface soils and prevent the infiltration of precipitation and subsequent leaching of contaminants

from the soils. The alternative also includes site security fencing and groundwater monitoring.

5.5.1.5.1 Performance

The soil-synthetic membrane cover and surface controls at Site D-16 will effectively minimize further leaching of contaminants by preventing infiltration of precipitation. The cap will be a permanent remedial action which will require routine maintenance.

Groundwater monitoring will establish whether or not groundwater has been contaminated, and if so, the potential for offsite migration. The surface cap in combination with site security fencing will be effective in eliminating the potential for direct contact with, or ingestion of, onsite contaminants.

This alternative meets 2 of the 3 objectives for remedial action in that it controls further migration of soil contaminants and protects against human exposure to the contaminants. The alternative provides a long-term solution which requires only routine maintenance. The effectiveness rating is moderate and the useful life rating is high.

5.5.1.5.2 Reliability

The multilayer cap and associated drainage controls will require routine maintenance such as mowing, regrading to repair erosion and settlement, and cleaning and repairing drainage channels. In past applications at landfills and contaminated soil sites, this technology has been proven a reliable remedy.

Monitoring wells are designed to operate with a minimum of maintenance. Cap fittings locking mechanisms, bailers, and surface

seals will be inspected during each sampling effort along with redevelopment of the wells if the screens become clogged with silt. The use of groundwater monitoring wells is a well established and proven technology for the detection of contaminated groundwater.

The methodologies for the analysis of water samples for VOCs and TPH are well established and widely used. Quality assurance/quality control checks will be incorporated in the sampling and analysis procedures to increase the reliability of the analysis.

In evaluating the reliability of Alternative 7, the operations and maintenance rating is high and the demonstrated performance rating is high.

5.5.1.5.3 Implementability

Severe weather will affect the constructability of the multilayer cover and monitoring wells. The implementability of the monitoring system is the same as described under Alternative 2.

The time to implement this alternative will take approximately 1 year, depending upon weather conditions and the availability of equipment and materials. Implementation will involve design report preparation and review, preparation of drawings and specifications, and construction.

In evaluating the implementability of Alternative 7, the constructability rating is moderate, the time to implement rating is moderate. The alternative does not remove or reduce contamination, therefore, the time to reach beneficial results rating is low.

5.5.1.5.4 Safety

During construction of the multilayer cap and installation of the monitoring wells, workers may be exposed to elevated levels of

contaminants in soil or groundwater. Workers will follow all applicable OSHA guidelines for work on hazardous waste sites, wear personal protective clothing as required, and monitor ambient air continuously to avoid exposure to contaminants and explosive gasses. No smoking or flames will be allowed in work areas where open excavations or boreholes exist.

Residents in the surrounding areas should not be exposed to hazardous materials during the construction of the cover or the installation of the monitoring wells. Both the short-term and long-term safety ratings are high.

5.5.1.6 Alternative 9 - Excavation, Offsite Local Landfill

This alternative consists of the physical removal of soils at Site D-16 and transport to the Anchorage Regional Landfill for disposal. Groundwater monitoring is also included as a component of this alternative.

5.5.1.6.1 Performance

The removal of contaminated soil will effectively eliminate the migration of contaminated materials into groundwater or into surface runoff by removing the contaminant source and containing the contaminated material in a suitable landfill. Soil sampling will be used to determine the effectiveness of the removal operation. The monitoring wells installed under this alternative will provide data to assess potential groundwater contamination.

This alternative meets the objectives of the remedial action in that it removes contamination at the site, reduces further migration of

hazardous materials, prevents human exposure to contaminants, and provides a long-term solution that requires only routine maintenance. The effectiveness rating is high and the useful life rating is high.

5.5.1.6.2 Reliability

After removal of the contaminated soil, no maintenance of the site is necessary except for periodic sampling and maintenance of the monitoring wells. The reliability of the monitoring system is the same as described under Alternative 7. The removal of contaminants by soil excavation and landfill is a conventional method.

In evaluating the reliability of Alternative 9, the operations and maintenance rating is high and the demonstrated performance rating is also high.

5.5.1.6.3 Implementability

There are no site conditions which should adversely affect the constructability of this alternative. The time to implement this alternative will take approximately 1 year, depending on weather conditions and availability of contractors, equipment, and materials. Implementation will involve design report preparation followed by installation and startup of monitoring activities. The implementability of the monitoring system will be the same as described under Alternative 2. The time to cleanup the site to desired contaminant levels will be the same as the time for implementation, approximately 1 year.

In evaluating the implementability of Alternative 9, the constructability rating is high, the time to implement rating is moderate, and the time to achieve desired results is high. Beneficial results are provided immediately upon completion of the excavation.

5.5.1.6.4 Safety

During excavation of contaminated soil and installation of the monitoring wells, workers may be exposed to elevated levels of contaminants in soil or groundwater. Workers will follow all applicable OSHA guidelines for work on hazardous waste sites, wear personal protective clothing as required, and monitor ambient air continuously to avoid exposure to contaminants or explosive gases. No smoking or flames will be allowed in work areas where open excavations or boreholes exist.

Residents in the surrounding areas should not be exposed to hazardous materials during the excavation of soil or the installation of monitoring wells. The potential exists for exposure to the soil during transport to the landfill.

In evaluating the safety of Alternative 9, the short-term and long-term safety rating is high.

5.5.1.7 Alternative 10 - Excavation, Offsite Disposal in a RCRA-Permitted Landfill

This alternative is identical to Alternative 9 with the exception that excavated soils are transported to a permitted RCRA facility instead of a sanitary landfill. Groundwater monitoring is also included as a component of this alternative. Alternative 10 will be considered only in the event that further analysis of soil contaminants at Site D-16 indicate that the soil exceeds the limits established for disposal at the Anchorage Regional Landfill.

5.5.1.7.1 Performance

The performance of this alternative is identical to that of Alternative 9. The removal of soil will effectively eliminate the

TABLE 5-30. SUMMARY OF TECHNICAL FEASIBILITY EVALUATION

Remedial Action Alternatives	Criterion: Performance — Effectiveness	Performance — Useful Life	Reliability — Operation and Maintenance Requirements	Reliability — Demonstrated Performance
1 No Action				
2 Groundwater Monitoring, Groundwater Use Restrictions, Alternate Water Supply	Effective in reducing exposure to contaminants and protecting public health. Will not reduce toxicity or concentrations of contaminants.	Long-term solution requiring only routine maintenance.	Designed to operate with a minimum of maintenance. Routine services of pump parts and well screens may be necessary.	Monitoring and alternate water supplies are a proven effective method of minimizing exposure to contaminants.
	Effectiveness Rating - Low to Moderate	Useful Life Rating - High	O&M Rating - High	Demonstrated Performance Rating - High
3 Collection, Onsite Air Stripping, Surface Discharge	Will effectively reduce, contaminants in groundwater.	Long-term solution requiring routine maintenance.	Minimal maintenance of extraction wells and monitoring wells. The air stripping tower will require routine maintenance.	Well established and proven technology for the treatment of contaminated groundwater.
	Effectiveness Rating - High	Useful Life Rating - High	O&M Rating - Moderate	Demonstrated Performance Rating - High
6 Collection, Onsite UV/ Oxidation Treatment, Surface Discharge	Same as Alternative 3	Same as Alternative 3	Operator assistance required. Routine maintenance. Monitoring wells also require minor maintenance.	Relatively new technology for groundwater remediation. Pilot testing required.
	Effectiveness Rating - High	Useful Life Rating - High	O&M Rating - Low	Demonstrated Performance Rating - Low
7 Containment by Surface Capping	Multilayer cap will control migration of of contaminants.	Long-term solution requiring only routine maintenance.	Minor maintenance includes mowing, regrading and repairing of drainage channels. Monitoring wells also require minor maintenance.	In landfills, applying this technology has been proven reliable.
	Effectiveness Rating - Moderate	Useful Life Rating - High	O&M Rating - High	Demonstrated Performance Rating - High
9 Excavation, Sanitary Landfill	Contaminated soils effectively removed.	Long-term solution requiring no site maintenance other than monitoring.	Maintenance of monitoring wells only.	Proven reliable for eliminating direct contact with contaminants and minimizing the potential for groundwater contamination.
	Effectiveness Rating - High	Useful Life Rating - High	O&M Rating - High	Demonstrated Performance Rating - High
10 Excavation RCRA Landfill	Same as Alternative 9	Same as Alternative 9	Same as Alternative 9	Same as Alternative 9
	Effectiveness Rating - High	Useful Life Rating - High	O&M Rating - High	Demonstrated Performance Rating - High

TABLE 5-30 (Continued). SUMMARY OF TECHNICAL FEASIBILITY EVALUATION

	Criterion			
	Implementability			
	Constructability		Time	
Remedial Action Alternatives	Site Conditions	Conditions External to Site	To Implement	To See Desired Results
1 No Action				
2 Groundwater Monitoring Groundwater Use Restrictions, Alternate Water Supply	Locations of monitoring wells will be dictated by current locations of runways and hangers.	Severe weather limitations may affect construction.	Approximately one year.	Does not reduce contamination.
	Constructability Rating - Moderate		Time to Implement Rating - Moderate	Time to Desired Resulting Rating - Low
3 Collection, Onsite Air Stripping, Surface Discharge	Locations of extraction wells and air stripping tower will be dictated by current locations of runways and hangers.	Severe weather limitations may affect construction. Heavily contaminated soils must be transported out of state.	Approximately one to two years.	Three to seven years.
	Constructability Rating - Moderate		Time to Implement Rating - Moderate	Time to Desired Results Rating - Moderate
6 Collection, UV/ Oxidation Treatment, Surface Discharge	Locations of extraction wells and treatment system will be dictated by runway and hangar locations.	Same as Alternative 3.	Same as Alternative 3	Same as Alternative 3
	Constructability Rating - Moderate		Time to Implement Rating - Moderate	Time to Desired Results Rating - Moderate
7 Containment by Surface Capping	Site restrictions to ensure cap integrity.	Same as Alternative 3.	Approximately one year.	Does not reduce contamination.
	Constructability Rating - Moderate		Time to Implement Rating - Moderate	Time to Desired Resulting Rating - Low
9 Excavation, Sanitary Landfill	No site restrictions.	Same as Alternative 3.	Approximately one year.	Immediately upon implementation of alternative.
	Constructability Rating - High		Time to Implement Rating - Moderate	Time to Desired Results Rating - High
10 Excavation RCRA Landfill	Same as Alternative 9	No RCRA landfill. Soils must be transported out of state.	Same as Alternative 9	Same as Alternative 9
	Constructability Rating - Moderate		Time to Implement Rating - Moderate	Time to Desired Results Rating - High

TABLE 5-30 (Continued). SUMMARY OF TECHNICAL FEASIBILITY EVALUATION

Remedial Action Alternative	Criterion: Safety — Worker Health and Safety	Criterion: Safety — Surrounding Populace
1 No Action		
2 Groundwater Monitoring, Groundwater Use Restrictions, Alternate Water Supply	Short-Term: Potential exposure to contaminated groundwater during installation. Long-Term: No exposure. Short-Term Safety Rating - High	Short-Term: No exposure. Long-Term: No exposure. Long-Term Safety Rating - High
3 Collection, Onsite Air Stripping, Surface Discharge	Short-Term: Potential exposure to contaminated soil and groundwater during installation. At Site SP-5/5A where trenching may occur, proper shoring is required to insure worker safety. Long-Term: Potential exposure to contaminated groundwater during operation and maintenance, minimal exposure to air emissions. Short-Term Safety Rating - High	Short-Term: No exposure. Long-Term: Potential low exposure to air emissions from air stripping tower. Long-Term Safety Rating - High
6 Collection, Onsite UV/Oxidation Treatment, Surface Discharge	Short-Term: Potential exposure to contaminated soil and groundwater during installation. At Site SP-5/5A where trenching may occur, proper shoring is required to insure worker safety. Long-Term: Potential exposure to contaminated groundwater during operation and maintenance. Short-Term Safety Rating - High	Short-Term: No exposure. Long-Term: No exposure. Long-Term Safety Rating - High
7 Containment by Surface Capping	Short-Term: Potential exposure to contaminated soil. Long-Term: No exposure. Short-Term Safety Rating - High	Short-Term: No exposure. Long-Term: No exposure. Long-Term Safety Rating - High
9 Excavation, Sanitary Landfill	Short-Term: Potential exposure to contaminated soil during excavation and removal. Long-Term: No exposure. Short-Term Safety Rating - High	Short-Term: Potential exposure to dust from excavated soil during removal. Long-Term: No exposure. Long-Term Safety Rating - High
10 Excavation, RCRA Landfill	Short-Term: Potential exposure during removal of contaminated soil. Long-Term: No exposure. Short-Term Safety Rating - High	Short-Term: Potential exposure to dust from contaminated soil during excavation and removal. Long-Term: No exposure. Long-Term Safety Rating - High

5.5.2 Environmental Impacts

This section provides an environmental analysis for each alternative in terms of both beneficial and adverse impacts. Criteria for evaluating beneficial effects are final environmental conditions, improvements in the biological environment, and improvements in human use resources. Criteria for evaluating adverse effects are the expected effect of the remedial action and the measures taken in the event that inevitable or irreversible effects could be realized. The environmental analysis focuses on site problems and pathways of contamination actually addressed by each alternative. The no action alternative is presented to serve as a baseline for the analysis.

The specific environmental media of most concern which may be impacted by remedial alternatives include groundwater and surface waters. The 2 surface water bodies which could potentially be impacted are Ship Creek and Cherry Hill Ditch. Both surface water streams discharge to Knik Arm. Site D-16 primarily concerns soil contamination, however, the potential for migration of contaminants from the site into groundwater, and eventually surface water remains a potential threat to the environment. The no action alternative provides a baseline analysis of environmental impacts.

For each alternative, the environmental impacts are rated on the following scale:

- High - Alternative minimizes damage to the environment.
- Moderate - Adverse environmental impacts are generally limited, controllable, and within acceptable limits.
- Low - Alternative causes uncontrollable or unacceptable effects.

The environmental analysis and ratings are summarized in Table 5-31 which is presented at the end of this section.

5.5.2.1 Alternative 1 - No Action

5.5.2.1.1 Beneficial Effects

This alternative does not provide any beneficial effects since no remedial actions are undertaken.

5.5.2.1.2 Adverse Effects

In the absence of remediation, the major adverse effects which will occur are continued migration of groundwater contaminants and eventual discharge into surface waters. If base wells in the pathway of migrating groundwater plumes are not sampled and taken out of service when contaminated, human consumption of volatile organic compounds becomes a possibility. Site SP-5/5A poses a more direct threat to surface waters from an active seep area where fuel product is being released into a nearby field area. If left uncontrolled, the released fuel will continue to cause die-off of vegetation and also continue to pose a threat to surface and groundwater supplies. Volatilization of the fuel product into the atmosphere is also occurring, however, impacts on ambient air quality are believed to be minimal. Wildlife in the area could be exposed to contamination through ingestion of surface waters and/or vegetation at the seep area. However, the threat to wildlife was assessed as low at Site SP-5/5A in the RI.

The actual impact on surface waters from plume migration in groundwater is unknown. The time of travel and concentration at discharge points cannot be determined without additional groundwater monitoring, hydrogeologic characterization, and transport modeling. Samples analyzed from Ship Creek have not shown evidence of BETX

contamination. However, the visible evidence of petroleum contamination at Cherry Hill Ditch may be associated with releases from sites evaluated in this study. Trout fishing is permitted in Ship Creek, however, it is not known if fish are present in waters at Cherry Hill Ditch. Wildlife could be impacted by exposure to contaminated surface water at Cherry Hill Ditch. The main adverse impact associated with the no action alternative for Site D-16 is the potential for uncontrolled migration of soil contaminants into surface and groundwater.

5.5.2.1.2 Environmental Impact Rating

Because the no action alternative does not provide beneficial results and causes uncontrolled impacts on the environment, a low environmental impact rating is given for all sites.

5.5.2.2 Alternative 2 - Groundwater Monitoring, Groundwater Use Restrictions, Alternate Water Supply

5.5.2.2.1 Beneficial Effects

The alternative does not contain, remove, or treat contaminated groundwater. However, because groundwater supplies are monitored periodically and an alternative supply made available, the potential for human ingestion of contaminants is substantially reduced. The potential risk to surface waters is more clearly assessed by continued monitoring of plume migration.

5.5.2.2.2 Adverse Effects

Alternative 2 does not contain, reduce or remove contaminants from any site. Groundwater remains contaminated and the active seep area at Site SP-5/5A remains a threat to the environment by continued

uncontrolled release of fuel product to the surface. The same impacts on wildlife and vegetation as discussed under alternative 1 also exist under this alternative.

5.5.2.2.3 Environmental Impact Rating

Under Alternative 2, the groundwater remains contaminated, however, the potential for ingestion of contaminated water supplies is substantially reduced. Also, the actual impact of groundwater contaminants on surface waters is more clearly defined. The alternative is, therefore, given an environmental impact rating of low to moderate for Sites IS-1, SP-7/7A, and SP-15. Site SP-5/5A is given a low rating because of the continued uncontrolled release of fuel product into the environment.

5.5.2.3 Alternative 3 - Collection, Onsite Air Stripping, Surface Discharge

5.5.2.3.1 Beneficial Effects

Under this alternative, contaminated groundwater is removed and treated to reduce contaminant levels to drinking water standards. Continued groundwater monitoring assures that the plume is effectively captured by the extraction system and therefore groundwater, drinking water supplies and surface water bodies are protected. The seep area at Site SP-5/5A is effectively contained and controlled by the interceptor trench system.

5.5.2.3.2 Adverse Effects

In this alternative the treated effluent is discharged directly to surface waters. The discharge point is Knik Arm which is a salt water body. Marine discharge limits for protection of the environment are

generally set higher than drinking water standards. Since contaminant concentrations are reduced to below drinking water standards, impacts on surface waters should be minimal. Atmospheric discharge of VOCs from the air stripping unit will meet air emission standards and impacts on ambient air quality should also be minimal. If required, off-gas treatment can be added to the system.

Potential adverse effects during construction and operation include leaks and spills of contaminated liquid from process overflow or ruptured piping. Mitigative measures to prevent such occurrences are incorporated into the treatment system design and include double wall construction on all piping and tanks, liquid level controllers, and containment structures for tanks holding separated fuel product or chemical reactants. Regular inspections of all process equipment and monitoring of effluent are also a requirement.

5.5.2.3.3 Environmental Impact Rating

This alternative minimizes groundwater contamination and controls the release of fuel product at Site SP-5/5A. The potential adverse effects are easily mitigated. Therefore, the environmental impact rating is high.

5.5.2.4 Alternative 6 - Collection, Onsite UV/Oxidation, Surface Discharge

This alternative includes the same beneficial and adverse effects as described for Alternative 3 except that releases of VOCs into the atmosphere are much lower and the potential exists for release of ozone gas. The potential release of ozone gas is easily mitigated by incorporating process controls, monitoring, and automatic emergency shut-off systems. Alternative 6 has the additional advantage of providing destruction of contaminants. and therefore. overall

environmental impacts to the atmosphere and to surface waters are lower than with other alternatives. Therefore, the environmental impact rating is high.

5.5.2.5 Alternative 7 - Containment by Surface Capping

5.5.2.5.1 Beneficial Effects

Capping the source area at Site D-16 reduces leaching of contaminants from soil and minimizes the potential for contaminant migration by erosion into surface runoff and by infiltration into the underlying aquifer. In addition, groundwater monitoring at the site provides the information necessary to determine whether or not groundwater has been contaminated, and if so, the potential for offsite migration.

5.5.2.5.2 Adverse Effects

Alternative 7 contains the source of contamination but does not remove or reduce contaminants at the site. No other construction or operational related impacts on the environment are involved.

5.5.2.5.3 Environmental Impact Rating

Because Alternative 7 controls and minimizes transport of contaminants into surface and groundwater but leaves contaminants in place, a rating of moderate is given.

5.5.2.6 Alternative 9 - Excavation, Offsite Local Landfill

5.5.2.6.1 Beneficial Effects

This alternative provides removal of the contaminated soil at Site D-16. The soil is transported to an offsite landfill which provides

containment of the soil and eliminates the potential for migration into groundwater. Groundwater and soil monitoring are utilized at the site to measure the effects of cleanup and to assess the potential for groundwater contamination.

5.5.2.6.2 Adverse Effects

Since contaminated soils are removed from the site, the potential adverse impact on the environment at the site is minimal. Groundwater monitoring will establish whether or not water resources are impacted. The potential for a spill when trucking waste soil is remote, and the adverse environmental effects are negligible because the spill would be easily cleaned up. The potential for improper disposal at the regional landfill exists. However, releases into the environment are mitigated to a certain extent by the presence of a high density polyethylene liner and a groundwater monitoring system.

5.5.2.6.3 Environmental Impact Rating

Alternative 9 provides removal of source contaminants at the site and the adverse effects are easily monitored or mitigated. Therefore, the environmental impact rating is high.

5.5.2.7 Alternative 10. Excavation, Offsite RCRA Landfill

This alternative provides the same beneficial and adverse effects as Alternative 9 except that landfill containment and monitoring requirements are much more stringent and the likelihood of improper disposal is reduced. Therefore, the environmental impact rating is high.

TABLE 5-31. SUMMARY OF ENVIRONMENTAL IMPACTS ANALYSIS

Remedial Action Alternatives	BENEFICIAL EFFECTS Final Environmental Conditions	BENEFICIAL EFFECTS Improvements in Biological Environment	BENEFICIAL EFFECTS Improvements in Human Use Resources	ADVERSE EFFECTS Construction/Operation	ADVERSE EFFECTS Mitigative Measures
1 No Action	Continued migration of contaminants, discharge of contaminants to surface waters, potential contamination of drinking water supplies, no significant impacts to air, continued release of fuel at Site SP-5/5A.	None.	None.	Continued migration of contaminants and ultimate discharge to surface waters. Potential contamination of drinking water supplies.	No action alternative, therefore, no mitigative measures will be taken.
Environmental Impact Rating - Low					
2 Groundwater Monitoring, Groundwater Use Restrictions, Alternate Water Supply	Groundwater remains contaminated, water supplies are monitored, potential for human ingestion is substantially reduced, continued release of fuel at SP-5/5A.	None.	Reduces potential risk of ingesting contaminated water supplies.	No construction related adverse effects.	No mitigative measures.
Environmental Impact Rating Low-Moderate for Sites IS-1, SP-7/10, SP-15. Low for Site SP-5/5A.					
3 Collection, Onsite Air Stripping, Surface Discharge	Contaminated groundwater is removed, contaminant levels are reduced to drinking water standards, treated effluent is discharged to Knik Arm, no significant impacts on air quality.	Contaminated groundwater is removed, releases of fuel at SP-5/5A are contained and treated.	Drinking water supplies are protected, discharge waters meets drinking water standards.	Minimal impacts on ambient air quality, leaks and spills of contaminated liquid.	Treatment of off-gases if required, double wall construction of piping and tanks, regular inspections, monitoring, process controls.
Environmental Impact Rating - High					
6 Collection, Onsite UV/Oxidation, Surface Discharge	Same as Alternative 3.	Same as Alternative 3.	Same as Alternative 3.	Same at Alternative 3, potential release of ozone gas.	Ozone gas releases are mitigated by process controls, automatic shut down, and monitoring.
Environmental Impact Rating - High					
7 Containment by Surface Capping	Leachate production is minimized, duration and concentration of contaminants discharged to surface and groundwater are minimized, no significant impacts to air.	Reduces concentration and duration of contaminants discharged to surface and groundwater.	Reduces potential for contamination of surface and groundwater.	No construction related adverse effects.	No mitigative measures.
Environmental Impact Rating - Moderate					
9 Excavation, Offsite: Local Landfill	Same as Alternative 7 plus contaminated soils are removed.	Minimizes concentration and duration of contaminants discharged to surface and groundwater.	Minimizes potential for contamination of surface and groundwater.	Potential for spillage of waste soil during transportation. Potential for improper landfill.	Transporter is required to institute cleanup measures. Landfill has liner and monitoring system.
Environmental Impact Rating - High					

TABLE 5-31 (Continued). SUMMARY OF ENVIRONMENTAL IMPACTS ANALYSIS

	BENEFICIAL EFFECTS			ADVERSE EFFECTS	
Remedial Action Alternatives	Final Environmental Conditions	Improvements in Biological Environment	Improvements in Human Use Resources	Construction/ Operation	Mitigative Measures
10 Excavation, Offsite RCRA Landfill	Same as Alternative 9.	Same as Alternative 9.	Same as Alternative 9.	Same as Alternative 9.	Same as Alternative 9.
		Environmental Impact Rating - High			

5.5.3 Public Health Impacts

The evaluation of public health impacts includes a site-specific endangerment assessment and an alternative-specific public health evaluation. The endangerment assessment estimates potential harm to public health from each site when no remedial actions are taken, i.e. the no action alternative. The public health evaluation analyzes the public health risks during implementation of an alternative (i.e. short term risks) and after it has been completed (i.e. long term risks). The risks associated with alternative can then be compared to the risks when no remedial action is taken to determine the extent to which each alternative mitigates potential public health threats.

5.5.3.1 Endangerment Assessment

This endangerment assessment is an estimation of the magnitude and probability of actual or potential harm to public health caused by actual or potential releases of hazardous substances to soil and groundwater. The assessment presents the potential human health effects associated with the 7 sites (D-16, IS-1, SP-5/5A, SP-7/10, SP-15) selected in the feasibility study. This assessment uses data generated in the RI. Waste locations and quantities and the extent of contaminant migration have not been totally defined; therefore, this assessment represents currently identified site conditions and those conditions estimated for areas of potential migration. Since Elmendorf AFB is a government facility, it is assumed that access to all sites will remain restricted in the future.

Groundwater sample analysis at sites revealed concentrations of metals and volatile organic compounds exceeding State and/or Federal Maximum Contaminant Levels (MCLs) or other regulatory guidelines. However, it is the concentrations of total recoverable metals which exceed applicable standards. The concentrations of dissolved metals are much

lower and do not exceed the MCLs. For the reasons explained in Section 4.1.2, it is believed that the high levels of total recoverable metals are due to improper well development. Therefore, it is assumed the high metal concentrations are due to soil phenomena and, consequently, are not a long-term contamination problem. Moreover, the endangerment assessment will not address risks associated with metals and will be limited to the risks associated with the organic compounds. Table 5-32 lists the potency factors and the EPA Weight of Evidence for each of the following potentially carcinogenic organic compounds detected: benzene, bis(2-ethylhexyl) phthalate, methylene chloride, and 1,1-dichloroethene. Table 5-33 lists the noncarcinogenic compounds detected along with their chronic (AIC) and subchronic (AIS) acceptable intake values. The AIC is based on a lifetime (70-year) of exposure to contamination. The AIS is based on short-term exposure. Based on maximum concentrations present, toxicity data, and preliminary risk calculations, the contaminants benzene, ethylbenzene, toluene, and xylenes (BETX) have been selected for assessment at Sites SP-5/5A, SP-7/10, and SP-15. Methylene chloride will also be discussed at Site SP-5/5A. At Site IS-1, 1,1-dichloroethane, 1,1,1-trichloroethane, and bis(2-ethylhexyl) phthalate have been included with BETX for assessment. Sufficient data to perform a quantitative endangerment assessment at Site D-16 does not exist. The contamination data at the site is limited to total petroleum hydrocarbons (TPH) which have no published potency factor or allowable intake levels. The site will be assessed qualitatively.

Each site is evaluated assuming no remedial action is undertaken (i.e., the no action alternative). Human health risks were evaluated using procedures contained in the Superfund Public Health Evaluation Manual (EPA, 1986).

Lifetime cancer risks associated with each site are estimated based on the cancer potency factor, which is a relative measure of a chemical's

TABLE 5-32. TOXICITY DATA FOR POTENTIAL CARCINOGENIC EFFECTS

Contaminant	Oral Route: Potency Factor $(mg/kg/day)^{-1}$	Oral Route: EPA Weight of Evidence[a]	Inhalation Route: Potency Factor $(mg/kg/day)^{-1}$	Inhalation Route: EPA Weight of Evidence[a]
Benzene	2.90×10^{-2}	A	2.6×10^{-2}	A
Bis(2-ethyhexyl) phthalate	6.84×10^{-4}	B2		B2
Methylene Chloride	7.50×10^{-3}	B2	1.43×10^{-2}	B2
1,1 Dichloro-ethene	6.00×10^{-1}	C	1.16×10	C

Source: EPA 1986.

[a]EPA weight of evidence categories for potential carcinogens.

EPA Category	Description of Group	Description of Evidence
Group A	Human Carcinogen	Sufficient evidence from epidemiologic studies to support a causal association between exposure and cancer.
Group B1	Probable Human Carcinogen	Limited evidence of carcinogenicity in epidemiology studies.
Group B2	Probable Human Carcinogen	Sufficient evidence of carcinogenicity in animals, inadequate evidence of carcinogenicity in humans.
Group C	Possible Human Carcinogen	Limited evidence of carcinogenicity in animals.
Group D	Not Classified	Inadequate evidence of carcinogenicity in animals.
Group E	No Evidence of Carcinogenicity	No evidence of carcinogenicity in at least two adequate animal tests or in both epidemiologic and animal studies.

TABLE 5-33. WASTE COMPONENT TOXICITY DATA FOR POTENTIAL NONCARCINOGENIC EFFECTS

Waste Component	Oral Route Acceptable Intake		Inhalation Route Acceptable Intake	
	Subchronic (mg/kg/day)	Chronic (mg/kg/day)	Subchronic (mg/kg/day)	Chronic (mg/kg/day)
1,1,1-Trichloroethane		5.40×10^{-1}	1.10×10^{-1}	6.30
1,1-Dichloroethane	1.20	1.20×10^{-1}		
Ethylbenzene	9.70×10^{-1}	1.00×10^{-1}		
Toluene	4.30×10^{-1}	3.00×10^{-1}	4.30×10^{-1}	3.00×10^{-1}
Xylenes (mixed)	1.00×10^{-1}	1.00×10^{-2}	6.9×10^{-1}	4.00×10^{-2}
1,1-Dichloroethene(1)	-	9.00×10^{-3}		

Source: EPA, 1986.

Notes: (1) Possible carcinogen.

cancer-causing potential. Excess lifetime cancer risk is defined as the incremental increase in the probability of developing cancer compared to the background probability (i.e., if no exposure to site contaminants occurred). For example, a 10^{-6} excess lifetime cancer risk would represent the risk resulting from an exposure that is associated with an increase in cancer incidence by one case per million people exposed for a lifetime. In this assessment, excess lifetime cancer risks are based on contaminant ingestion averaged over a 5-year span, which is the estimated average potential for human exposure. Contaminant concentration is held constant in the environmental media over the exposure period. The lifetime cancer risk from exposure to an individual chemical in a given media can be estimated using the following model:

$$R = CDI \times PF \times EDR$$

where: R = Excess lifetime cancer risk

PF = Cancer potency factor $(mg/kg/day)^{-1}$

CDI = Chronic Daily Intake (mg/kg/day)

EDR = Exposure Duration Ratio

Thus, the larger the potency factor (given equal chemical concentrations) the greater the lifetime average cancer risk. The cancer potency factor is based on a lifetime exposure of 70 years. Therefore, a numerical ratio will be used to adjust the potency factor for a 5-year exposure. The CDI for adults is based solely on ingestion of 2 liters of contaminated groundwater and 0.1 grams of soil per day for 5 years from the sites. Potential exposure also exists via dermal contact or inhalation of contaminated soil particles. However, these pathways are not included in the assessment due to the limited site accessibility, the fact that the increased concentration occurred at subsurface levels, and the inability to identify intake levels (EPA, 1986). For children, the CDI may increase due to a higher ingestion rate of contaminated soil.

Children age 2 to 6 years may ingest 0.1 to 5 grams of soil per day, with the higher values reflecting pica behavior (the tendency to place foreign objects or foods in one's mouth). Access to the sites by children is considered limited, yet it will be assumed that a 10 kg child will consume 0.2 grams of soil per day from the sites for the purposes of the endangerment assessment. The total child intake is then based on a 10 kg child ingesting 0.2 grams of soil and 1 liter of water per day for 5 years. These ingestion rates are based on EPA risk assessment guidance documents (EPA, 1986) and an EPA memorandum (EPA, Jan. 27, 1989). An example calculation of excess lifetime cancer risk is shown in Table 5-34.

The risks associated with ingestion of the noncarcinogens (toluene, ethylbenzene, xylenes, and others) are assessed by comparing estimated daily intakes to acceptable intakes. Acceptable intakes for children and adults have been developed for subchronic (AIS) and chronic (AIC) exposure. The estimated daily intake levels are based on a 10 kg child drinking 1 liter of contaminated water and ingesting 0.2 grams of soil per day and a 70 kg adult drinking 2 liters of contaminated water and ingesting 0.1 grams of soil per day. The acceptable intake for subchronic exposure is the highest human intake of a chemical that does not cause adverse effects when exposure is short-term. The acceptable intake for chronic exposure is the highest human intake of a chemical that does not cause adverse effects when exposure is long-term (lifetime).

5.5.3.1.1 Site D-16

Site D-16 was used as a waste disposal site from the 1970's to 1983. Wastes disposed at the site included fuel tank residue and fuel filters. Analysis of soil samples taken from four boreholes at the site revealed elevated levels of total petroleum hydrocarbons (TPH) only. Samples were not analyzed for BETX compounds. Although TPH may pose a potential risk to human health, there are no guidelines on

TABLE 5-34. EXAMPLE CALCULATION OF EXCESS LIFETIME CANCER RISK DUE TO EXPOSURE

Example: Calculate the excess cancer risk due to an adult consuming water contaminated with benzene using the toxicity data in Table 5-32 and the risk model on page 5-80.

Assumption: Person weighs 70 kg (154 lb).
Person consumes 2L (1/2 gal) per day for 5 years
Concentration of benzene in water is 10 micrograms per liter (ug/L) which is equivalent to 10 parts benzene per billion parts of water.

Equation for Excess Lifetime Cancer Risk (R):

$$R = CDI \times PF \times EDR$$

where

PF = Cancer potency factor - 2.9×10^{-2} mg/kg/day^{-1} (Table 5-32)

CDI = lifetime average daily intake of benzene milligrams of benzene per kilogram of body weight per day

$$CDI = \frac{10\ ug}{L} \times \frac{mg}{1000\ ug} \times \frac{2L}{day} \times \frac{1}{70\ kg} = 2.86 \times 10^{-4}\ mg/kg/day$$

EDR = Exposure Duration Ration

$$EDR = \frac{5\ Years}{70\ Years}$$

then $$R = 2.86 \times 10^{-4}\ mg/kg/day \times 2.9 \times 10^{-2}\ mg/kg/day \times \frac{5\ Years}{70\ Years}$$

$R = 5.93 \times 10^{-7}$ or an excess risk of 6 in 10 million of getting cancer from consuming 2 liters per day of water containing 10 ug/L of benzene for 5 years.

which to base an assessment. Therefore, the risk at D-16 cannot be quantitatively assessed.

Primary paths of human exposure to contamination at Site D-16 would be through consumption of water from downgradient base supply wells, should they be contaminated, or ingestion of the contaminated soil. Currently, there is no data showing contamination of the shallow aquifer. Also, the lower aquifer, from which the majority of water supply wells draw, is protected by the Bootlegger Cove Formation. The one well that is in the shallow aquifer is not in the groundwater flow path from the site. Therefore, it is expected that base supply wells will not become contaminated. Ingestion of soil is also considered improbable considering the location and limited access to the site. The overall risk associated with Site D-16 is considered minimal.

5.5.3.1.2 Site IS-1

Site IS-1 has been the location of many small fuel spills. The largest documented spill was 1300 gallons. No fuel was known to have been recovered from these spills and it is assumed that the fuel seeped into the ground. Dry wells in the vicinity may have received rinse waters from shop operations in the past.

Preliminary subsurface investigations at the site indicate that the groundwater flow in the area of IS-1 is to the southwest. This direction would carry contaminated water towards Ship Creek and Knik Arm. Should the contaminants enter Ship Creek, potential human exposure exists through recreational contact with the water. However, water quality in Ship Creek has been good (Section 4.2.23). Therefore, risks associated with exposure via Ship Creek will not be considered. Potential human exposure to contaminants would most likely occur through ingestion of contaminated groundwater from downgradient wells or ingestion of contaminated soil by children, should they gain access to the site.

Contaminants Detected at the Site. Elevated levels of BETX were detected in groundwater during the RI at IS-1. In addition to BETX compounds, 1,1,1-trichloroethane, 1,1-dichloroethane, naphthalene, bis(2-ethylhexyl) phthalate (not as a laboratory contaminant), 2-methylnapthalene, and TPH were also detected. The contaminants considered in the endangerment assessment, with their maximum concentrations and associated risks, are presented in Table 5-35. Napthalene and 2-methylnapthalene were not included as no AIS or AIC values were available for these compounds.

Potential Carcinogenic Effects. Of the contaminants identified during the RI, both benzene and bis(2-ethylhexyl) phthalate are suspected carcinogens. Using the format presented in Table 5-34 and the concentration data in Table 5-35, the calculated excess lifetime cancer rate for adults are as follows:

- Benzene - 2.1×10^{-6}
- Bis(2-ethylhexyl)phthalate - 1.0×10^{-6}
- Total - 3.1×10^{-6}, or 3 excess cases of cancer per 1 million adults exposed to the contamination for 5 years.

If the group being exposed to the contaminants is children, the excess lifetime cancer risk rises slightly. This is due to a larger CDI during childhood. The excess lifetime cancer risk for a population exposed to the contamination as children is then calculated as:

- Benzene - 7.3×10^{-6}
- Bis(2-ethylhexyl)phthalate - 3.5×10^{-6}
- Total - 1.1×10^{-5}, or 11 excess cases of cancer per 1 million children exposed to the contamination for 5 years.

Potential Noncarcinogenic Effects. Noncarcinogens detected at IS-1 include ethylbenzene, toluene, xylenes, 1,1-dichloroethane, and

TABLE 5-35. CONTAMINATION AND RISKS AT SITE IS-1.

Carcinogens	Maximum Concentration Soil (ug/kg)	Maximum Concentration Water (ug/L)	Excess Lifetime Cancer Risk(1) Adults	Excess Lifetime Cancer Risk(1) Children
Benzene	ND	35	2.1×10^{-6}	7.3×10^{-6}
Bis(2-ethylhexyl) phthalate	ND	720	1.0×10^{-6}	3.5×10^{-6}

Noncarcinogens	Maximum Concentration Soil (ug/kg)	Maximum Concentration Water (ug/L)	Average Daily Intake(2) Adults	Average Daily Intake(2) Children
Ethylbenzene	ND	250	7.2×10^{-3}	2.5×10^{-2}
Toluene	ND	460	1.3×10^{-2}	4.6×10^{-2}
Xylene	ND	1,050	3.0×10^{-2}	1.1×10^{-1}
1,1,1 TCA	ND	3.1	8.9×10^{-5}	3.1×10^{-4}
1,1 DCA	ND	7.1	2.3×10^{-4}	7.1×10^{-4}

NOTES: (1) Adult risk based on 70 kg person consuming 2 L of water and 0.1 grams of soil per day for 5 years. Child risk based on 10 kg person consuming 1 L of water and 0.2 grams of soil per day for 5 years.

(2) Adult intake based on 70 kg person consuming 2L of water and 0.1 grams of soil per day. Child intake based on 10 kg person consuming 1L of water and 0.2 grams of soil per day.

ND - Not Detected

1,1,1-trichloroethane. The risks associated with the ingestion of these compounds are summarized below. The conclusions reached are a result of comparing Tables 5-33 and 5-35.

- Ethylbenzene - The daily intake level does not exceed the subchronic or chronic allowable intake levels for children or adults.
- Toluene - The daily intake level does not exceed the subchronic or chronic allowable intake levels for children or adults.
- Xylenes - The daily intake level exceeds both the subchronic and chronic allowable intake levels for children. This concentration also exceeds the chronic allowable intake level for adults.
- 1,1-dichloroethane - The daily intake level does not exceed the chronic or subchronic allowable intake level for children or adults.
- 1,1,1-trichloroethane - The daily intake level does not exceed the chronic or subchronic allowable intake level for children or adults.

IS-1 Summary. Site IS-1 has been the location of many small fuel spills. As a result of these spills, groundwater has become contaminated with BETX and other volatile organic compounds. Exposure to these contaminants would most likely occur through ingestion of contaminated groundwater pumped from downgradient base supply wells or ingestion of contaminated soil. At present, the deep aquifer that supplies base wells has not been effected by the contaminants. The contamination is isolated in the upper aquifer.

As mentioned in Section 5.5.3.1, it is highly unlikely that contaminant concentrations similar to those seen at this site would occur in the base drinking water wells. This is due to the Bootlegger Cove Formation, which separates the contaminated aquifer from the lower aquifer used for the majority of drinking water supply and the fact that the one supply well in the shallow aquifer is not in the groundwater flow path from the site. Also, it is unlikely that ingestion of soil would be a concern considering access to the site is very limited and the highest concentrations of contamination occurred at subsurface levels. Therefore, the overall risk associated with contamination at Site IS-1 is considered minimal.

5.5.3.1.3 Site SP-5/5A

This site has ' bulk fuel storage tanks (1,000,000 gallon capacity each) which are interconnected and gravity fed. Since their installation in the 1940's, the tanks have had numerous spills it is also suspected that the tanks and onsite piping may be leaking. Fuel from these tanks has been observed seeping from the hillside into a fuel/water separator and into a nearby ditch.

Information from borings located at SP-5/5A indicate that the site lies on a groundwater divide, with groundwater flowing in both a north-northwest and southeast directions. The northwesterly flow could result in contaminated water being discharged into Knik Arm and the southeasterly flow could result in contaminated water discharge to Ship Creek and eventually Knik Arm. Potential exposure to contaminants would most likely occur through consumption of groundwater from downgradient wells. Other potential exposure would come from direct contact with or ingestion of contaminated soil.

Contaminants Detected. Elevated levels of BETX and TPH were detected in both groundwater and soil samples during the RI. Minor amounts

(0.26 to 6.0 mg/kg) of ethanol and methylene chloride were also detected in several of the site soil borings, but not in groundwater. Contaminants used for the endangerment assessment, their maximum concentrations, and their associated risks are presented in Table 5-36.

Potential Carcinogenic Effects. Benzene and methylene chloride were the only carcinogens detected at this site. Benzene is the contaminant of greatest concern when concentrations, pathway of exposure, and potency factor are considered. The excess lifetime cancer risk, for adults, associated with this site is calculated to be 1.3×10^{-3}, or over 1 excess cancer case per 1,000 people. For children exposed to the contamination, the rate rises slightly to 4.4×10^{-3}, or over 4 excess cancer cases per 1,000 children.

Potential Noncarcinogenic Effects. Noncarcinogens detected at SP-5/5A include ethylbenzene, toluene, and xylenes. Comparison of Tables 5-33 and 5-36 shows the following:

- Ethylbenzene - The daily intake exceeds the chronic allowable intake for children. Neither subchronic nor chronic allowable levels for adults, nor subchronic levels for children, are exceeded.

- Toluene - The daily intake levels would significantly exceed both subchronic and chronic allowable intake levels for children and slightly exceed both allowable intake levels for adults.

- Xylenes - The daily intake would exceed both subchronic and chronic allowable intake levels for children and adults.

SP-5/5A Summary. Due to a lengthy history of fuel leaks, Site SP-5/5A soils and groundwater have become contaminated with variable levels of

TABLE 5-36. CONTAMINATION AND RISKS AT SITE SP-5/5A.

	Maximum Concentration		Excess Lifetime Cancer Risk[1]	
Carcinogens	Soil (ug/kg)	Water (ug/L)	Adults	Children
Benzene	ND	21,000	1.3×10^{-3}	4.4×10^{-3}
Methylene Chloride	5,000	ND	4.2×10^{-9}	5.9×10^{-8}

	Maximum Concentration		Average Daily Intake[2]	
Noncarcinogens	Soil (ug/kg)	Water (ug/L)	Adults	Children
Ethylbenzene	6,200	2,700	7.7×10^{-2}	2.7×10^{-1}
Toluene	6,600	26,000	7.4×10^{-1}	2.6×10^{0}
Xylene	27,000	10,900	3.1×10^{-1}	1.1×10^{0}

NOTES: (1) Adult risk based on 70 kg person consuming 2 L of water and 0.1 grams of soil per day for 5 years. Child risk based on 10 kg person consuming 1 L of water and 0.2 grams of soil per day for 5 years.

(2) Adult intake based on 70 kg person consuming 2L of water and 0.1 grams of soil per day. Child intake based on 10 kg person consuming 1L of water and 0.2 grams of soil per day.

ND = Not Detected

benzene, toluene, ethylbenzene, xylenes, and other chemicals. Potential exposure to these chemicals would most likely be through ingestion of contaminated groundwater pumped from base wells or ingestion of contaminated soil. At present, contamination is isolated in the upper aquifer and has not effected the lower aquifer where downstream base wells are located. Potential exposure to contaminants through direct contact with soil is also possible; however, it not likely.

For the same reasons discussed for Site IS-1, the overall risk associated with contamination at Site SP-5/5A is considered minimal.

5.5.3.1.4 Site SP-7/10

This site has been the location of several large and small JP-4 fuel spills. Two spills in particular (50,000 gallons in 1964-1965 and 36,000 gallons in 1980) have been documented. Little or no fuel was recovered from either of these spills which infiltrated the gravelly soil.

Preliminary subsurface investigations indicate that groundwater flow in the area of SP-7/10 is towards the southwest. This direction would carry contaminants towards Ship Creek which empties into the Knik Arm and, eventually, the Pacific Ocean. Potential human exposure to contaminants would be the same as those described for Site IS-1. As stated, the primary pathways of exposure are consumption of contaminated water from supply wells and ingestion of contaminated soil.

<u>Contaminants Detected at the Site</u>. Elevated levels of BETX were detected in both soil and groundwater during the RI at SP-7/10. Maximum levels detected and the risks associated with those levels are

presented in Table 5-37. The risks are discussed in the following sections. The contaminants detected were generally located to the west and north portion of the site. Pure JP-4 fuel was recovered from one of the onsite monitoring wells.

<u>Potential Carcinogenic Effects</u>. Of the indicator contaminants identified at this site, only benzene is a suspected carcinogen (Group A). Using the procedure shown in Table 5-34, the excess lifetime cancer rate for adults is calculated to be 1.9 x 10^{-4}, or 19 excess cancer cases per 100,000 people exposed to the contamination for 5 years. For children exposed to the contamination for 5 years, the rate rises to 6.7 x 10^{-4}, or 67 excess cases per 100,000 children.

<u>Potential Noncarcinogenic Effects</u>. Noncarcinogens detected at SP-7/10 included ethylbenzene, toluene, and xylenes. Comparison of Tables 5-33 and 5-37 yields the following conclusions about the contaminants:

- Ethylbenzene - The daily intake exceeds the chronic allowable intake level for children; it does not exceed the subchronic intake level. Neither subchronic or chronic adult allowable intake levels are exceeded.

- Toluene - The daily intake exceeds both the subchronic and chronic allowable intake levels for children. Neither subchronic or chronic adult allowable intake levels are exceeded.

- Xylene - The daily intake exceeds both the subchronic and chronic allowable levels for both adults and children.

<u>SP-7/10 Summary</u>. Because of large spills of JP-4 fuel in the vicinity, Site SP-7/10 soils and groundwater have become contaminated with variable levels of benzene, toiuene, ethlybenzene, and xylenes. Exposure to these contaminants would most likely be through the

TABLE 5-37. CONTAMINATION AND RISKS AT SITE SP-7/10.

Carcinogens	Maximum Concentration Soil (ug/kg)	Maximum Concentration Water (ug/L)	Excess Lifetime Cancer Risk[1] Adults	Excess Lifetime Cancer Risk[1] Children
Benzene	ND	3,200	1.9×10^{-4}	6.7×10^{-4}

Noncarcinogens	Maximum Concentration Soil (ug/kg)	Maximum Concentration Water (ug/L)	Average Daily Intake[2] Adults	Average Daily Intake[2] Children
Ethylbenzene	1,000	1,300	3.7×10^{-2}	1.3×10^{-1}
Toluene	1,200	7,100	2.0×10^{-1}	7.1×10^{-1}
Xylene	14,000	5,000	1.4×10^{-1}	5.0×10^{-1}

NOTES: (1) Adult risk based on 70 kg person consuming 2 L of water and 0.1 grams of soil per day for 5 years.
Child risk based on 10 kg person consuming 1 L of water and 0.2 grams of soil per day for 5 years.

(2) Adult intake based on 70 kg person consuming 2L of water and 0.1 grams of soil per day.
Child intake based on 10 kg person consuming 1L of water and 0.2 grams of soil per day.

ND = Not Detected

ingestion of contaminated groundwater pumped from the base wells or ingestion of contaminated soil by individuals with access to the site. For the same reasons discussed in Section 5.5.3.1.2, it is highly unlikely that contaminant concentrations similar to those seen at this site would occur in the base drinking water wells. Also, it is unlikely that ingestion of soil would be a concern considering access to the site, which is located near a runway, is very limited. Therefore, the overall risk associated with contamination at Site SP-7/10 is considered minimal.

5.5.3.1.5 Site SP-15

This site was the location of a 1000 gallon AVGAS spill in 1961. The majority of the spill was contained; however, some of the fuel was lost when it seeped into the ground.

Two borings installed at the site were converted into monitoring wells. Information obtained from these wells indicates groundwater flow is to the southwest. This flow direction could have contaminated groundwater being discharged to Ship Creek which eventually empties into Knik Arm.

Contaminants Detected at the Site. Data obtained from monitoring well samples indicate that groundwater at SP-15 contained elevated levels of BETX and TPH. Soil samples taken from borings were found to contain ethylbenzene, toluene, xylenes, and TPH. The maximum concentrations of the contaminants detected, along with the associated risks, are shown in Table 5-38.

Potential Carcinogenic Effects. Benzene was the only chemical detected at Site SP-15 that is suspected of causing cancer. The lifetime cancer rate associated with contamination at this site is 1.0×10^{-5} or an excess risk of 10 in 1 million people. The excess

TABLE 5-38. CONTAMINATION AND RISKS AT SITE SP-15.

Carcinogens	Maximum Concentration Soil (ug/kg)	Maximum Concentration Water (ug/L)	Excess Lifetime Cancer Risk(1) Adults	Excess Lifetime Cancer Risk(1) Children
Benzene	ND	170	1.0×10^{-5}	3.5×10^{-5}

Noncarcinogens	Maximum Concentration Soil (ug/kg)	Maximum Concentration Water (ug/L)	Average Daily Intake(2) Adults	Average Daily Intake(2) Children
Ethylbenzene	21,000	100	2.9×10^{-3}	1.4×10^{-2}
Toluene	13,000	300	8.6×10^{-3}	3.3×10^{-2}
Xylene	91,000	410	1.2×10^{-2}	4.3×10^{-2}

NOTES: (1) Adult risk based on 70 kg person consuming 2 L of water and 0.1 grams of soil per day for 5 years. Child risk based on 10 kg person consuming 1 L of water and 0.2 grams of soil per day for 5 years.

(2) Adult intake based on 70 kg person consuming 2L of water and 0.1 grams of soil per day. Child intake based on 10 kg person consuming 1L of water and 0.2 grams of soil per day.

ND - Not Detected

lifetime cancer rate for children exposed to the contamination rises to 3.5×10^{-5}, or 35 excess cancer cases per 1 million people.

Potential Noncarcinogenic Effects. Noncarcinogens detected at Site SP-15 included ethylbenzene, toluene, and xylenes. The risks associated with the ingestion of these chemicals are summarized below:

- o Ethylbenzene - The daily intake does not exceed any allowable intake levels for children or adults.

- o Toluene - The daily intake level does not exceed subchronic or chronic allowable intake levels for children or adults.

- o Xylenes - The daily intake level exceeds the children's and adults' chronic allowable intake level. It does not exceed the subchronic for either.

SP-15 Summary. Site SP-15 was the location of a 1000 gallon AVGAS spill in 1961. As a result of this spill, soil and groundwater have become contaminated with BETX compounds. Exposure to these contaminants would most likely occur through ingestion of contaminated groundwater pumped from base wells or ingestion of soil. At present, the deep aquifer that downstream base wells pump from has not been effected. It is not likely that it will become contaminated as it is separated from the shallow, contaminated aquifer.

For the same reasons explained in Section 5.5.3.1.2 for Site IS-1, the overall risk associated with contamination at this site is considered minimal.

5.5.3.2 Public Health Evaluation

The public health evaluation of alternatives assesses the extent to which each alternative mitigates long-term exposure to any residual

contamination and protects public health both during and after completion of remedial action. Remedial actions protect human health by meeting or exceeding ARARs or health-based threshold concentration limits.

In evaluating both long- and short-term public health impacts, there are 2 primary areas which must be considered. First. there must be an exposure or a potential exposure to the contaminant for the recipient's health to be affected adversely. If there is no exposure, there will be no adverse health effects. Potential pathways of exposure were discussed in the previous section. The second area requiring consideration in the evaluation of alternatives is the relationship of the actual concentration of the contaminant to published exposure limits or threshold limits. Both areas must be considered to properly evaluate the impact an alternative might have on public health.

Evaluation of short-term impacts will consider health effects on workers during construction of the remedial action and on the public for the interim period prior to remedial action implementation. Long-term impacts will be judged based on the chronic intake of the contaminant over the lifetime of the remedial action.

Alternatives for both the short-term and long-term are evaluated on the following scale:

- High - Alternative prevents intake and incidental contact with contaminant concentrations that exceed limits established by ARARs.
- Moderate - Alternative prevents intake but allows incidental contact with contaminant concentrations that exceed limits established by ARARs.

- Low - Alternative allows for intake of contaminants at concentrations above ARARs and threshold limits.

A summary of the public health evaluation for each of the alternatives is provided in Table 5-40 at the end of this section.

5.5.3.2.1 Alternative 1 - No Action

The endangerment assessment presented in Section 5.5.3.1 describes the public health impacts associated with the no action alternative. The primary exposure route of concern for contaminants migrating from 6 of the 7 sites at Elmendorf (SP-7/10, SP-5/5A, SP-15, and IS-1) would be drinking water from contaminated wells or ingestion of contaminated soil. The observed maximum groundwater levels of benzene and bis(2-ethylhexyl) phthalate are 21,000 ug/L and 720 ug/L, respectively. As discussed in the endangerment assessment, other noncarcinogenic chemicals will be present in elevated concentrations also. Potential exposure due to contact with contaminated soil is present at Site D-16. The only contaminant detected at D-16 was TPH. As indicated in the endangerment assessment, there are potential health risks involved with exposure to elevated levels of TPH; however, there are currently no guidelines by which to assess the risks.

For the purpose of establishing a baseline for comparison of the other alternatives, the evaluation of public health impacts for the no action alternative will assume that no further monitoring will take place. The risks involved with ingestion of carcinogens and noncarcinogens are the same as those discussed in the endangerment assessment. The lifetime cancer risk values range from 3 to 4,400 excess cases of cancer per 1 million people exposed to these levels for 5 years.

Since it is estimated that the MCL for benzene, a carcinogen, will be exceeded in groundwater, and up to 1,300 excess cases of cancer per one million adults, or 13 excess cases among the approximately 10,000 adults on the base, should they be exposed for 5 years, could occur, a rating of low will be given to the no action alternative for both short-term and long-term health impacts.

5.5.3.2.2 Alternative 2 - Groundwater Monitoring, Groundwater Use Restrictions, Alternate Water Supply

By supplying all residents who are in the path of potential contaminant plume migration with an alternate water supply, the exposure to contaminants is essentially eliminated. However, a potential exposure still exists via ingestion of contaminated soil. The potential is small considering the limited accessibility of the site, especially to children. The calculations of excess lifetime cancer risks from ingestion of carcinogens in groundwater are the same as those under the no action alternative when no alternate water supply is provided. Again, the predominant long-term risk is due to ingestion of benzene and bis(2-ethylhexyl) phthalate. The increased risk of cancer if a 70 kg adult consumes 2 liters of benzene contaminated groundwater (at a concentration of 21,000 ug/L, the maximum concentration detected) for 5 years is about 1.3 in 1,000. If the residents are hooked up to an alternate water supply prior to contamination reaching their wells, there is no exposure, and therefore, no increased cancer risk. There potentially could be short-term exposure to carcinogens in groundwater if a residence is not connected to an alternate water supply prior to carcinogens being detected in samples. The excess cancer risks in adults associated with short-term exposure to these carcinogens (four months) at the maximum concentration detected, is 8.4×10^{-5} for benzene and 6.4×10^{-8} for bis(2-ethylhexyl) phthalate. If contamination were to reach the drinking water supply wells, the actual concentrations

initially detected would be much lower than the current maximum concentrations, such as 100 ug/L for benzene. The short-term excess cancer risk in adults for consumption of this concentration of benzene for four months is 3.9×10^{-7}.

Short-term and long-term exposure to noncarcinogens may occur if alternate water supplies are not provided prior to contamination of drinking water. Levels of noncarcinogens in groundwater could exceed allowable AIS levels for xylene and toluene as discussed in the endangerment assessment. If alternate water supplies are provided prior to contamination of drinking water or at initial indications of well contamination, no or minimal exposure is likely to occur.

The purpose of the monitoring program is to provide sufficient time to hook up residents to alternate water supplies prior to contamination of their drinking water supply. Construction activities would present minimal short-term health risks to workers. If alternate water supplies are not connected prior to contaminants reaching base supply wells, residents may receive short-term exposure. The short-term health rating is moderate and the long term health rating is high.

5.5.3.2.3 Alternative 3 - Collection, Onsite Air Stripping, Surface Discharge

In comparison to the no action alternative, public health impacts will be reduced substantially by this alternative. Groundwater cleanup levels, shown in Table 5-7, are based on proposed ADEC Cleanup Standards. Those levels are used here to assess public health impacts. The potential exposure from ingestion of soil is also considered. These public health impacts assessments are considered very conservative, for the following reasons:

o The primary path of exposure would be consumption of water contaminating these levels of contamination. It is very

unlikely that the base wells, which supply the drinking water for the base, would become contaminated to this level. This is due to the fact that the majority of base wells draw from a lower artesian aquifer which is separated from the shallow contaminated aquifer by the low permeability Bootlegger Cove Formation. The one supply well that is in the shallow aquifer is not in the path of groundwater flow from the contaminated sites.

- The assessment is based on all BETX compounds being consumed at the maximum allowable concentrations. It is likely that the treatment process will reduce most of the contaminant concentrations to levels below the cleanup standards.

Only BETX compounds have been used to evaluate short and long-term health impacts. All other contaminants proved to be at levels which already meet ARARs.

Extraction well placement in this alternative significantly reduces the downgradient maximum predicted concentrations of carcinogens. The excess lifetime cancer risk associated with consuming water with benzene concentrations equal to the treatment level (5 ug/l, equal to proposed ADEC level) for 5 years is 2.9×10^{-7} for adults and 1.0×10^{-6} for children exposed to the contamination. This represents under 1 excess cancer case per 1 million adults. The rate raises slightly to approximately 1 case per 1 million for children. As discussed earlier, these are conservative estimates. Noncarcinogenic compound concentrations will also be considerably lower downgradient of the extraction wells.

As presented in Table 5-39, the predicted health risks are much lower than the potential exposure under the no action alternative.

TABLE 5-39. COMPARISON OF NONCARCINOGEN HEALTH RISKS, ALTERNATIVES 3 AND 6

	Health Risks			
	No Action		After Remedial Action (1)	
	Maximum Intake Level (2)		Intake at Target Cleanup Level	
Contaminant	Adult (3)	Children (4)	Adult (5)	Children (6)
Ethylbenzene	7.7×10^{-2}	2.7×10^{-1}	2.0×10^{-2}	7.0×10^{-2}
Toluene	7.4×10^{-1}	2.6×10^{0}	5.7×10^{-2}	2.0×10^{-1}
Xylene	3.1×10^{-1}	1.1×10^{0}	1.3×10^{-2}	4.4×10^{-2}

(1) Based on ADEC proposed levels. Water will be treated to ADEC levels.

(2) All maximum intake levels occurred at Site SP-5/5A.

(3) Based on consumption of 2L of water and 0.1 grams of soil per day by 70 kg person.

(4) Based on consumption of 1L of water and 0.2 grams of soil per day by 10 kg child.

(5) Based on consumption of 2L of water per day by a 70 kg person.

(6) Based on consumption of 1L of water per day by 10 kg child.

Comparison of Tables 5-39 and 5-33 show that the subchronic allowable intake (AIS) for xylene is still exceeded for both adults and children. The daily intake exceeds the AIS by much less than an order of magnitude and, considering the conservative nature of the prediction as discussed earlier, is not expected to cause adverse health effects. Also, this prediction reflects risks associated with consumption of xylene concentrations in equal to the proposed ADEC regulations.

The potential exposure to adults and children via soil ingestion are not considered in the predicted health risks. The highest concentrations of BETX compounds detected at Sites SP-5/5A and SP-15 occurred in the saturated zone and therefore will be mitigated by the groundwater collection and treatment, as discussed in Section 5.2.3. Considering this, the inaccessibility of the site, and the fact that the high concentrations occurred at subsurface levels which would make it extremely unlikely that individuals would be exposed, the risks associated with soil ingestion are negligible.

There is a potential for short-term health impacts during the installation, operation, and maintenance of the treatment facilities, If all regulations and guidelines are followed, the exposure potential will be minimal. Treatment plant personnel should be aware of the nature of the waste stream they are treating and utilize appropriate personal protection equipment. Air emissions from the stripping tower should not affect the health of workers or the health of local residents.

The short-term health impact rating is moderate and the long-term health impact is high.

5.5.3.2.4 Alternative 6 - Collection, UV/Oxidation Treatment, Surface Discharge

The health impacts are the same as described for Alternative 3 except there will be no off-gasses from air strippers containing contaminants. The contaminants are destroyed by oxidation in this treatment technology, thus there is no potential release of contaminants and no potential long-term exposure pathways. The short-term health rating is moderate and the long-term health rating is high.

5.5.3.2.5 Alternative 7 - Containment by Surface Capping

Alternative 7 is only applicable to Site D-16. Elevated levels of TPH have been observed in soil only. Other contaminants have not been detected in soils. A groundwater investigation has not been performed at this site. By covering the soil under a multilayer cap and diverting surface water around the area, the exposure to contaminants in soil and the potential for contaminants to migrate into groundwater is greatly reduced. The predominant long-term risk is due to direct contact or inhalation of contaminated soil. This risk, which is already slight considering limited accessibility to the site, would be further mitigated by the installation of a multilayer cap.

The purpose of groundwater monitoring with this alternative is to determine the effectiveness of the cap in eliminating contaminant migration into groundwater and to determine whether groundwater contamination currently exists and requires remediation. Construction activities involving the cap and monitoring wells would present potential short-term health risks to workers only. If proper precautions are taken and all safety guidelines and regulations are followed, exposure to workers would be minimal. Currently, there are no guidelines for risks involving TPH. It is assumed that health

risks associated with TPH are no greater than the risks for BETX compounds. Both the short-term and long-term health ratings are therefore high.

5.5.3.2.6 Alternative 9 - Excavation and Disposal at Offsite Sanitary Landfill

Alternative 9 is only applicable to Site D-16. Elevated levels of TPH have been observed in soil only. Other contaminants have not been deleted. A groundwater investigation has not been performed. By removing contaminated soil to a properly engineered landfill the exposure at the site to contaminants in soil and the potential for contaminants to migrate into groundwater at the site is eliminated. The predominant short-term risk is due to ingestion or inhalation of contaminated soil.

The purpose of groundwater monitoring with this alternative is to determine the effectiveness of the soil removal in eliminating contaminant migration into groundwater and to determine whether groundwater contamination currently exists and requires remediation. Construction activities involving the removal of soil and installation of groundwater monitoring wells would present potential short-term health risks to workers only. For the same reasons as Alternative 7, the short and long-term health ratings are considered high.

5.5.3.2.7 Alternative 10 - Excavation and Disposal at Offsite RCRA-Permitted Landfill

The health impacts are the same as described for Alternative 9 except that soils would be hauled over long distances in order to be disposed at RCRA facilities. By following RCRA transportation guidelines, no additional adverse health impacts are anticipated. Therefore, the short- and long-term health ratings are considered high.

TABLE 5-40. SUMMARY OF PUBLIC HEALTH IMPACTS

Remedial Action Alternatives	Criterion: Long-Term Impacts	Criterion: Short-Term Impacts
1 No Action	Does not reduce migration of contaminants and does not eliminate potential exposure to contaminants at concentrations which pose a potential health risk. Long-Term Impact Rating - Low	With no remediation contaminants could migrate to base wells which could cause potential health risks due to exposure to contaminants. Short-Term Impact Rating - Low
2 Groundwater Monitoring, Groundwater Use Restrictions, Alternate Water Supply	Alternate water supply and groundwater use restrictions eliminate potential exposure to contaminated groundwater. Long-Term Impact Rating - High	Potential for exposure to contaminated groundwater during construction of monitoring system to both workers and residents. Short-Term Impact Rating - Moderate
3 Collection, Onsite Air Stripping, Surface Discharge	Reduces contaminant concentrations. Coupled with groundwater monitoring, eliminates exposure to contaminants in groundwater and mitigates exposure via soil ingestion. Contaminants removed from water are discharged to atmosphere. Long-Term Impact Rating - High	Potential for exposure during construction of extraction system, potential for exposure during operation and maintenance of treatment facilities. Short-Term Impact Rating - Moderate
6 Collection, Onsite UV/ Oxidation Treatment, Surface Discharge	Same as Alternative 3, except contaminants are destroyed, not discharged to atmosphere. Long-Term Impact Rating - High	Same as Alternative 3. Short-Term Impact Rating - Moderate
7 Containment by Surface Capping	Multimedia cap and surface water diversion will effectively reduce migration of contaminants into groundwater and mitigate potential exposure to contaminated soil. Long-Term Impact Rating - High	Workers may be exposed to contaminated soil during installation of the cap. No published criteria for TPH exposure. Short-Term Impact Rating - High
9 Excavation and Disposal at Offsite Sanitary Landfill	Does not reduce contaminant concentration. Removes contaminants from areas of potential exposure to permitted landfill. No published criteria for TPH exposure. Long-Term Impact Rating - High	Potential for exposure to contaminants during excavation and removal of soil. No published criteria for TPH exposure. Short-Term Impact Rating - High
10 Excavation and Disposal at Offsite RCRA-Permitted Landfill	Does not reduce contaminant concentration. Removes contaminants from areas of potential exposure to a RCRA approved landfill. Long-Term Impact Rating - High	Same as Alternative 9, plus potential exposure during transportation of soil to RCRA-permitted landfill in the Continental U.S. Short-Term Impact Rating - High

5.5.4 Institutional Requirements

This section presents the institutional requirements evaluation of the detailed alternatives for the FS sites. These requirements are divided into 4 categories: conformance with potentially applicable or relevant and appropriate requirements (ARARs), permitting requirements, community concerns, and state acceptance. The institutional requirements evaluation is summarized in Table 5-41 at the end of this section.

5.5.4.1 Evaluation Criteria

Potential ARARs were identified in Section 5.1. It must be recognized that the standards and regulations actually involved for the remediation at any site are subject to the discretion of the lead agencies. For this reason, the remedial alternatives are evaluated with respect to pertinent federal, state, and local regulations. In the overall evaluation, qualitatively higher weighting is assigned to existing ARARs and lower weighting to the proposed regulations. Conformance with ARARs is evaluated on the following scale:

- High - Alternative will meet or exceed existing ARARs.
- Medium - Alternative does not attain ARARs but will reduce the likelihood of present or future threats to public health or environment from hazardous substances.
- Low - Alternative violates ARARs.

The community concerns evaluation addresses the public's perceived acceptance of the selected remedial action alternatives. This material may be expanded in the Final RI/FS report to incorporate concerns expressed by the public during the public comment period.

Public input to the selection process and acceptance of the chosen alternative is important to the success of the remediation effort.

Community concerns are evaluated on the following scale:

- o High - Alternative is acceptable to the public and will receive public support.
- o Medium - Alternative will meet with some public resistance, however, it will be accepted as a positive remediation effort.
- o Low - Alternative will meet with public resistance and will not be accepted.

The community concerns evaluation will be amended to include concerns expressed during the public meeting on the FS Report. Likewise, the ratings may be revised to reflect the perceived acceptance of the alternatives at the time of public review.

Permitting requirements are evaluated on the amount of effort required to conform to permitting standards. Since the sites are not NPL sites federal, state, or local permits will be required for both onsite and offsite activities. Remedial actions that involve storage, treatment or disposal of hazardous substances at offsite facilities will involve only such offsite facilities that are operating under appropriate Federal and state permits and other legal requirements. For example, several alternatives evaluated require removal of hazardous substances (soil or spent carbon) to offsite facilities. Both the transporter of these wastes and the disposal facility that receives the wastes would be required to have a permit or authorization under the appropriate regulations. A National Pollution Discharge Elimination System

(NPDES) Permit will be required for discharges of treated water to surface waters. Review and approval by ADEC of construction reports, plans, and specifications, for any treatment facility will also be required before any remedial action can be implemented.

The alternatives are evaluated according to the following scale:

- o High - Permits would not be required or would be easily obtained.

- o Moderate - Permits would be obtained with reasonable effort.

- o Low - Permits would be very difficult to obtain or would be unobtainable.

This portion of the institutional requirements evaluation addresses expected acceptance of each alternative by state agencies. Consideration has been given to the following items when evaluating state acceptances:

- o Ability to obtain approvals from state agencies.
- o Activities needed to coordinate with other agencies.
- o Additional legal issues which may affect state agency acceptance of alternatives.

State acceptance is evaluated on the following scale:

- o High - Alternative is acceptable to the state agencies and implementation of the alternative requires minimal coordination with other agencies.

- o Medium - Alternative will meet some resistance from state regulatory agencies and coordination efforts with other agencies will be complicated.

- o Low - Alternative is not acceptable to State regulatory agencies and coordination with other agencies is difficult.

5.5.4.2 Alternative 1 - No action

Conformance with ARARs. The regulations identified to date which pertain to this alternative are the following:

- o RCRA, Subtitle C for protection of groundwater.
  Six of the sites included in the FS can be considered similar to a hazardous waste facility which has released hazardous contaminants into the groundwater. (No groundwater samples were collected or analyzed at Site D-16.) Such releases trigger a "corrective action program that prevents hazardous constituents from exceeding their respective concentration limits at the compliance point by removing the hazardous waste constituents or treating them in place" (40 CFR 264.100(b)).

- o SDWA, Maximum Contaminant Levels (MCLs).
  The drinking water in wells near the sites could become contaminated as the plumes continue to migrate. However, this is unlikely because contamination was detected in shallow groundwater and base wells are located in the lower artesian aquifer at depths of 160 to 200 feet. MCLs for some compounds could be exceeded in water taken from the wells.

Alternative 1 does not meet the intent of the potential ARARs primarily because the groundwater remains contaminated. The conformance to ARARs rating is low.

Community Concerns. Selection of this alternative would not alleviate potential community concerns regarding contaminated soil at Site D16

and groundwater at Sites IS-1, SP-5/5A, SP-7/10, and SP-15. Persons using well water may question the safety of the water supply. The community concerns rating is low.

Permitting Requirements. No permits are required for the no action alternative; however, the ADEC must approve the remedial action selected for each site. Since state acceptance of the no action alternative is unlikely, the permitting rating is low.

State Acceptance. Minimal coordination would be required with regulatory agencies; however, the state regulatory agencies may not accept the no action alternative. The state acceptance rating is low.

Based on the low evaluations for each category presented above, the overall institutional requirements rating for Alternative 1 is low.

5.5.4.3 Alternative 2 - Groundwater Monitoring Groundwater Restrictions, Alternate Water Supply

Conformance with ARARs. The regulations identified to date which pertain to this alternative are the following:

- RCRA, Protection of Groundwater
  This alternative does nothing to address contamination in the groundwater, and so does not conform to the RCRA regulations to protect groundwater It does protect public health through monitoring and provision of an alternate water supply if necessary; therefore, one intent of the groundwater protection regulations is meet.
- SDWA, Maximum Contaminant Levels (MCLs)
  The drinking water in wells near the sites could become contaminated as the plume continue to migrate. However,

this is unlikely because contamination was detected in shallow groundwater and base wells are located in the lower artesian aquifer at depths of 160 to 200 feet. MCLs for some compounds could be exceeded in water taken from the wells.

Because only partial conformance with groundwater protection regulations exist, despite the fact that human health is protected, the conformance to ARARs rating of Alternative 2 is moderate.

Community Concerns. The lack of groundwater treatment or plume migration control may be perceived as an inadequate solution. However, the potential risk of drinking contaminating water will be eliminated. A moderate rating is assigned as some, but not all, community concerns are addressed.

Permitting Requirements. The only permits required for Alternative 2 are construction permits for expanding the existing water supply. In addition, legal issues will need to be addressed which pertain to restricting groundwater use if the aquifer which supplies the base wells becomes contaminated. A moderate permitting requirements rating is given to this alternative.

State Acceptance. A moderate state acceptance rating is given to this alternative because the alternative eliminates the potential negative impacts to public health from ingestion of contaminated drinking water; however, it does not reduce the mobility, toxicity, or volume of contaminants in the groundwater.

Based on the evaluations presented above, the overall institutional requirements rating is moderate.

5.5.4.4 Alternative 3 - Collection, Onsite Air Stripping Surface Discharge

Conformance with ARARs. The regulations identified to date which pertain to this alternative are the following:

- RCRA, Protection of Groundwater.
  By preventing the spread of contamination into new areas of groundwater, the content of RCRA to protect the "offsite" migration of contamination is met.

- SDWA, MCLs.
  Potential impacts to the drinking water supply are eliminated and the groundwater is treated to meet the MCLs for contaminants, so the Safe Drinking Water Act will be adhered to.

- OSHA.
  Any onsite remediation must comply with OSHA regulations regarding appropriate health and safety procedures.

Currently there are no standards regulating the concentration of off-gases from air stripping units, other than threshold limit values (TLV's) for gases in occupied areas. In the event that regulations change and off-gas treatment becomes necessary, technologies such as vapor phase carbon adsorption or catalytic combustion can be incorporated into the system to meet the requirements of new ARARs.

EPA published the final rule on the management of and corrective action for USTs in the September 23, 1988 Federal Register. The rule became effective on December 22, 1988. Since the tanks at Site SP-5/5A are part of a airport hydrant fuel system, they are deferred leak detection requirement.

Because the intent of pertinent regulations is met for Alternative 3, a high rating is given on the conformance to ARARs criteria.

Community Concerns. In general, Alternative 3 receives a high rating for addressing community concerns because the groundwater is remediated and future negative impacts from the sites to drinking water is eliminated or minimized.

Permitting Requirements. The alternative will require an NPDES permit for discharging the treated water to Knik Arm via the storm sewer. This permit should be easily obtainable. The state must approve the design of the treatment plant which will take a reasonable amount of effort. Therefore, a moderate permitting requirements rating is given to this alternative.

State Acceptance. The technologies which makeup this alternative are all proven in remediating similar sites, meet ARARs, improve the environment and protect public health. Therefore, it is assumed that the alternative will be acceptable to the state. A high state acceptance rating is given to this alternative.

Based on the evaluations presented above, the overall institutional requirements rating is high.

5.5.4.5 Alternative 6 - Collection, Onsite UV/Oxidation, Surface Discharge

Conformance to ARARs. Because Alternative 6 differs from Alternative 3 only in that onsite UV/Oxidation replaces air stripping, most of the pertinent regulations are common to both alternatives. Specifically,

drinking water MCLs and RCRA groundwater protection. Because the intent of pertinent regulations is met, as discussed for the most part in Section 5.5.4.3 for Alternative 3, a high rating is given on the conformance to ARARs criteria. UST regulations also apply to Site SP-5/5A and will have been addressed.

Community Concerns. The remediation provided by this alternative is essentially equivalent to that of the previous alternative in that further contamination migration is prevented and the groundwater is treated. Therefore, the community concerns rating is high.

Permitting Requirements. The permitting requirements of Alternative 6 are the same as Alternative 3; therefore, a moderate permitting requirements rating is given to this alternative.

State Acceptance. The treatment technology for this alternative has not been field tested to the same degree as the treatment technology for Alternative 3; however, this alternative does meet ARARs, improves the environment and protects public health. Since the alternative is very similar to Alternative 3 except that UV/Oxidation is relatively new to groundwater remediation, a moderate state acceptance rating is given.

Based on the evaluations presented above, the overall institutional requirements rating is moderate to high.

5.5.4.6 Alternative 7 - Containment by Surface Capping

Conformance to ARARs. This in-place containment of materials at Site D-16 can be considered similar to a closure of a RCRA landfill. Restricting access, providing a multi-layer cap over contamination areas and monitoring groundwater, approaches compliance with RCRA closure. Since the alternative does not attain ARARs but reduces the

likelihood of present or future threats to public health and the environment from hazardous substances, a moderate rating is given.

Community Concerns. Since long-term management of the site is required because the contaminated soil is left onsite, there may be some unfavorable community response. However, the potential for coming in contact with contaminants is minimized. The community concerns rating is moderate.

Permitting Requirements. The state must approve the in-place closure of the contaminated soil which will take a reasonable amount of effort; therefore, a moderate permitting requirements rating is given to this alternative.

State Acceptance. A moderate state acceptance rating is given to this alternative. The alternative may meet with some resistance because the contaminants remain on site, in addition, state approval of the cap design must be obtained.

Based on the evaluations presented above, the overall institutional requirements rating is high.

5.5.4.7 Alternative 9 - Excavation and Offsite Sanitary Landfill

Conformance to ARARs. This alternative will only be considered if the soil at Site D-16 is determined to be a nonhazardous waste and average TPH levels remain below 1000 ppm. Therefore, the local requirement that TPH concentrations to be less than 1000 ppm applies to this alternative. RCRA is pertinent to this alternative only in regards to protection of groundwater. OSHA regulations also apply to this alternative. Since the soil will be taken to the local landfill only if average TPH values are less than 1000 ppm and groundwater monitoring wells will be installed to determine if contamination from

the site has reached the groundwater, the conformance to ARARs rating is high.

Community Concerns. If this alternative is implemented, the contaminated soil is not considered hazardous and is removed and landfilled in the Anchorage Regional Landfill; therefore this alternative should be acceptable to the public. The community concerns rating is high.

Permitting Requirements. The sanitary landfill must be permitted and a permit from the state will be required to close the site. Site closure should be readily obtainable; therefore, a high permitting requirements rating is given to this alternative.

State Acceptance. This alternative should be acceptable to the state as it meets ARARs and contaminated soil is removed from the site; therefore, a high state acceptance rating is given.

Based on the evaluations presented above, the overall institutional requirements rating is moderate.

5.5.4.8 Alternative 10 - Excavation and Offsite RCRA - Permitting Landfill Disposal

Conformance with ARARs. This alternative will only be considered if the soil at Site D-16 is determined to be a hazardous waste and average TPH values exist above 1000 ppm. RCRA is pertinent to this alternative in regards to protection of groundwater at the site and disposal of hazardous waste in a RCRA-permitted facility. DOT requirements pertaining to the transportation of hazardous waste are pertinent to the alternative. These requirements include: (1) containers must be designed and constructed to prevent significant releases to the environment, (2) must be properly marked as hazardous

waste, labeled, and placarded for shipment, and (3) emergency response procedures must be developed for spill incidents. All load limit restrictions must be observed in shipment of waste from the site. OSHA requirements must also be followed. Since groundwater monitoring wells will be installed to determine groundwater quality, the soil will be disposed of at a RCRA-permitted facility, and DOT and OSHA regulations will be followed the conformance to ARARs rating is high.

<u>Community Concerns</u>. Since the contaminated soil is removed from the area and landfilled in a RCRA-permitted facility, this alternative should be acceptable to the public. However, there could be some opposition to transporting hazardous waste through the community. Therefore, the community concerns rating is moderate.

<u>Permitting Requirements</u>. The offsite disposal facility must have a RCRA permit and a permit from state will be required to close the site. Site closure should be readily obtainable therefore, a high permitting requirements rating is given to this alternative.

<u>State Acceptance</u>. This alternative should be acceptable to the state as it meets ARARs and contaminated soil is removed from the site; therefore, a high state acceptance rating is given to this alternative.

Based on the evaluations presented above, the overall institutional requirements rating is high.

TABLE 5-41. SUMMARY OF INSTITUTIONAL REQUIREMENTS ANALYSIS

Remedial Action Alternatives	Criterion: Conformance with ARARs	Community Concerns	Permitting Requirements	State Acceptance
1 No Action	Does not contain, remove or treat the existing contaminated soil and/or groundwater. Rating: Low	Alternative will not alleviate community concerns that environment is contaminated and plumes are not monitored. Rating: Low	Does not meet the intent of groundwater protection. Rating: Low	May not be acceptable to State since sites are not remediated or monitored. Rating: Low
2 Groundwater Monitoring, Groundwater Use Restrictions, Alternate Water Supply	Does not contain, remove or treat the existing contaminated soil and/or groundwater. Protects public health. Rating: Moderate	Lack of groundwater and soil cleanup may be perceived as an inadequate solution. Rating: Moderate	Approval of Remedial Action may be difficult to obtain. Rating: Moderate	State acceptance of an alternative that leaves hazardous contaminants in place may be difficult. Rating: Moderate
3 Collection, Onsite Air Stripping, Surface Discharge	Groundwater will eventually meet MCLs. Contaminants will be removed and treated thus meeting environmental protection regulations. No ARARs for soil remediation. Rating: High	Displays concern by governmental agency and shows a high involvement in an environmental cleanup. Potential impacts to base wells and surface water minimized or eliminated. Rating: High	Meets objectives of groundwater protection and meets discharge requirements. Currently no air emissions requirements. State approval of design will take reasonable amount of effort. Rating: Moderate	Should be acceptable to State as ARARs are met, permits are obtainable and the technologies are proven in remediating similar sites. Rating: High
6 Collection, Onsite UV/Oxidation, Surface Discharge	Same as Alternative 3. Rating: High	Same as Alternative 3. Rating: High	Same as Alternative 3. Rating: Moderate	Similar to Alternative 3 except UV/Oxidation has not been field tested to to same degree as air stripping. Rating: Moderate
7 Containment by Capping	Landfill-type cap minimizes future contamination but does nothing to remove, contain, or treat existing contamination. Rating: Moderate	Potential for contact with contaminants is minimized; however, leaving contaminated soil in place may receive unfavorable community response. Rating: Moderate	Permit for in-place closure of Site must be obtained. Rating: Moderate	Alternative may meet with some resistance as contaminants are left in-place. Rating: Moderate
9 Excavation and Offsite Sanitary Landfill	Meets ARARs, removes contaminated soil from site. Rating: High	Potential for contact with contaminants is eliminated, alternative should receive favorable community response. Rating: High	Permits are not required for onsite remediation but may be required to close the site. Rating: High	Alternative remediates site and should be acceptable to state agencies. Acceptable if average TPH values are under 1000 mg/kg. Rating: High
10 Excavation and Offsite RCRA-Permitted Landfill	Same as Alternative 9. (Use only if soil is a hazardous waste.) Rating: High	Similar to Alternative 9 except there may be opposition to transporting hazardous waste through community. Rating: Moderate	Closure permits similar to those required of a hazardous waste landfill may be required. Rating: High	Same as Alternative 9. Alternative is only required if average TPH values are greater than 1000 mg/kg and/or hazardous contaminants are detected. Rating: High

5.5.5 Cost Analysis

The detailed cost analysis involves estimating both the capital and annual operation and maintenance (O&M) costs for each alternative at each site. Once these estimates have been completed, the present worth of each alternative can be calculated and a comparative evaluation can be made.

5.5.5.1 Cost Estimates

The cost estimates presented here are based on conceptual designs prepared for the alternatives, not detailed engineering data. The goal established by USAFOEHL and EPA guidance documents in calculating these estimates is to be accurate within +50 percent and -30 percent. Actual costs could vary within this range due to unforeseen ancillary costs. The cost estimates are prepared in accordance with EPA documents on estimating costs of remedial actions at hazardous waste sites. The actual costs of the project will depend on the final scope and design of the selected alternative, the implementation schedule, competitive market conditions, and other variables. These factors are not expected to affect the relative costs between alternatives. Because of these factors, funding requirements must be carefully reviewed before making specific financial decisions or estimating final budgets.

The development of cost estimates for the alternatives include:

- Estimation of the capital costs, including construction, equipment, transportation, site development, engineering and design, and contingency costs.

- Estimation of the annual O&M costs (including power, inspection, maintenance, monitoring and cleaning, and

sampling costs) over the life of the remedial action following initial implementation.

- Calculation of the present worth of the alternative utilizing the capital and annual costs, a 9.375 percent discount rate, and an estimated project life of 3 years. No equipment salvage value is considered. Inflation is not considered.

Construction costs include cost of materials, labor, equipment, and transportation of equipment to Alaska (Nancy Smith, Crowley Maritime, personal communication, 1989) necessary to construct and implement the alternative. Such items as site preparation, installation of monitoring and extraction wells, treatment plant construction, and contaminated material disposal are also considered in this category. Indirect capital costs include engineering and design, permitting and legal, construction services, insurance, and bid and scope contingency costs. Indirect costs were estimated as a percentage of total construction costs. Operation and maintenance costs were calculated for activities that continue after original implementation of the remedial action. These include monitoring of groundwater and treatment plant effluent quality; routine operation and maintenance of onsite treatment equipment, groundwater extraction wells, and product recovery systems; routine maintenance and inspection of surface water diversion berms and multilayer caps; and general site inspection.

Unit costs were obtained from EPA documents (EPA, 1985; EPA, 1987); construction cost guides (The Guide, 1988); estimates from similar hazardous waste projects (Black & Veatch, 1987; CH2M Hill et al, 1988); and estimates provided by equipment vendors, hazardous waste transporters, and treatment and disposal facility operators.

Present worth analysis is used to provide a basis for overall cost comparison for each alternative at each site by taking future costs that occur at various times and discounting them to the present year. Present worth is the amount of capital required to be deposited at the present time at a given interest rate to yield the total amount necessary to fund the remedial action to completion. The present worth values can be compared to determine the truly relative costs of the various alternatives applicable to each site. A discount rate of 9.375 percent was used for each alternative. The effect of varying the discount rate from 5 to 15 percent is addressed in Section 5.5.5.7, Cost Sensitivity Analysis.

Initial capital costs were considered to occur in year zero. O&M costs were considered to occur annually for 3 years, the average estimated project duration. The effect of a varying the necessary project duration is also addressed in Section 5.5.5.7.

5.5.5.2 Contingencies, Allowances, and Assumptions

Because these cost estimates are conceptual and not based on detailed engineering data, contingencies and allowances, discussed below were estimated to account for unknown costs. The size of the contingencies vary according to the magnitude of the estimated construction cost and level of uncertainty associated with the alternative.

- Bid Contingency - A bid contingency of 10 to 25 percent of the construction cost was used to cover unknown costs associated with a given project scope, such as adverse weather conditions and geotechnical/hydrogeological unknowns.

- Scope Contingency - A scope contingency of 10 to 35 percent was used to cover unknown costs pertaining to project scope.

- Permitting and Legal - Three to 15 percent of the construction cost was assumed to address permitting requirements and legal fees.

- Services During Construction - Five to 15 percent of the construction cost was assumed for supervision and administration which includes construction management, onsite observation, change order negotiations, submittal reviews and office services, and engineering and design during construction.

- Engineering Design Cost - An engineering design cost was estimated at 3 to 35 percent of the construction cost depending upon the complexity of the alternative and the magnitude of the construction cost.

Estimated capital, annual, and present worth costs for each alternative are discussed in the following sections. Detailed cost breakdowns are presented in Appendix N.

General assumptions common to all alternatives are as follows:

- Productivity during construction will be decreased due to the need for Level D protection for workers directly exposed to contaminated material. It is expected that the majority of work will be performed in Level D protection. Also, vehicle decontamination will be necessary for any vehicles that come into contact with contaminated materials.

- A site health and safety supervisor will be on the property during all phases of activity involving direct worker exposure to contaminated materials.

- All unit costs used pertaining to site development work in the continental U.S. were increased by 30 percent considering average price differences between the continental U.S. and Alaska.

Certain factors may substantially affect the estimated costs of the alternatives. These factors are discussed in Section 5.5.5.7, following the discussion of each alternative.

5.5.5.3 Alternative 1 - No Action

This alternative applies to both soil and groundwater remediation. Therefore, it applies to all sites.

No costs are associated with this alternative because no remedial actions are undertaken.

5.5.5.4 Alternatives Pertaining to Contaminated Soil Remediation.

The following alternatives pertain to Site D-16. A summary of these alternative costs is shown in Table 5-42 following the discussion on the alternatives. The detailed cost breakdowns are presented in Appendix N.

5.5.5.4.1 Alternative 7 - Containment by Surface Capping

The major capital cost components of this alternative include installation of groundwater monitoring wells, construction of a security fence around the site, construction of a berm around the site to control surface water flow, and installation of a multilayer cap on the site to prevent infiltration. Berm and multilayer cap construction are based on clearing and rough grading of the 1.5 acre site, installation of clay, synthetic liner, sand, filter fabric, native soil backfill, and topsoil layers, and seeding the site with native vegetative cover. Major annual costs include groundwater

TABLE 5-42. SUMMARY OF REMEDIAL ALTERNATIVE COSTS (PHASE III): SITE D-16

Alternative	Capital Cost ($1000s)	Annual Cost ($1000s)	Present Worth[1] ($1000s)
1 No Action	0	0	0
7 Containment by Surface Capping	841	7.68	909[2]
9 Excavation, Offsite Sanitary Landfill Disposal	1,930	10.0	1,950
10 Excavation, Offsite RCRA-Permitted Disposal	8,770	8.07	8,790

Notes: (1) Based on 9 3/8% discount rate for a three year project duration.

(2) Alternative 7 based on 20 year project duration due to containment, not removal, of contamination.

monitoring and site inspection and mowing. The groundwater monitoring costs are based on quarterly sampling of the new monitoring wells. Each sample will be analyzed for VOCs and TPH. The present worth of this alternative, $909,000 as shown in Table 5-42, is based on a 20 year project duration. This duration is longer than than other alternatives due to containment, not removal, of contaminants.

5.5.5.4.2 Alternative 9 - Excavation and Disposal at Offsite Sanitary Landfill

Capital costs for this alternative include installation of groundwater monitoring wells, construction of a security fence around the perimeter of the site, excavation of the contaminated soil, transportation and disposal of the contaminated soil at a sanitary landfill (The Anchorage Regional Landfill), backfill of the area with native soil, and seeding of the area. Considering the short distance from the site to the local sanitary landfill (less than three miles), the excavation and transportation are considered as one unit cost (The Guide, 1988). Major annual costs for this alternative are similar to those described in Alternative 7. In this alternative, however, there will be no surface water diversion berm to inspect and maintain. The present worth of this alternative, based on a three year project duration is $1.95 million.

5.5.5.4.3 Alternative 10 - Excavation and Disposal at Offsite RCRA-Permitted Landfill

Major capital and annual costs for Alternative 10 are the same as those for Alternative 9. However, the unit costs for transportation and disposal of the contaminated soil rise considerably since that the soil must now be transported to a RCRA-permitted landfill. Estimated costs for RCRA-permitted landfill disposal were provided by Chemical Waste Management, Inc. personnel (Rieff, personal communication,

1989). The soil could be accepted at RCRA-permitted landfills in Arlington, Oregon or Clive, Utah. The soil would be transported to the landfill from the site as follows: The soil would be loaded into gondola freight cars onsite; the freight cars would be sealed; the soil would be transported via rail to Whittier, Alaska; there it would be loaded, while still in the freight cars, onto a barge; the barge would deliver the freight cars to Seattle, Washington; the freight cars would be downloaded onto rails; the cars would travel by rail to the RCRA landfill; the soil would be unloaded from the cars and disposed of. Budgetary level cost estimates for the transportation of the contaminated soil were provided by Alaskan Railroad personnel (Morrow, personal communication, 1989).

The present worth of Alternative 10 is $8.79 million.

5.5.5.5 Alternatives Pertaining to Groundwater Remediation

The following alternatives pertain to remedial actions at Sites IS-1, SP-5/5A, SP-7/10, and SP-15. A summary of the costs for these alternatives are presented, by site, in Tables 5-43 to 5-46. These tables are presented after the discussion of the alternatives. Detailed cost breakdowns are presented in Appendix N.

5.5.5.5.1 Alternative 2 - Groundwater Monitoring, Groundwater Use Restrictions, Alternate Water Supply

This alternative involves monitoring groundwater at all sites and restricting use of the contaminated aquifer. Five new monitoring wells will be installed. Nine monitoring wells and 3 water supply wills will be sampled quarterly for volatile organic compounds (VOCs) and total petroleum hydrocarbons (TPH). Major cost components for this alternative include capital costs for installation of new monitoring wells and annual costs for collecting and analyzing

TABLE 5-43. SUMMARY OF REMEDIAL ALTERNATIVE COSTS (PHASE III): SITE IS-1

Alternative	Capital Cost ($1000s)	Annual Cost ($1000s)	Present Worth(1) ($1000s)
1 No Action	0	0	0
2 Groundwater Monitoring, Groundwater Use Restrictions, Alternative Water Supply	27.5	28.9	285(2)
3 Collection, Onsite Air Stripping, Surface Discharge	372	70.2	548
6 Collection, Onsite UV/Oxidation, Surface Discharge	849	290	1,530

Notes: (1) Based on 9 3/8% discount rate for a three year project duration.

(2) Alternative 2 based on 20 year project duration due to monitoring, not removal, of contamination.

TABLE 5-44. SUMMARY OF REMEDIAL ALTERNATIVE COSTS (PHASE III): SITE SP-5/5A

Alternative	Capital Cost ($1000s)	Annual Cost ($1000s)	Present Worth[1] ($1000s)
1 No Action	0	0	0
2 Groundwater Monitoring, Groundwater Use Restrictions, Alternative Water Supply	27.5	28.9	285[2]
3 Collection, Onsite Air Stripping, Surface Discharge	2,830	68.5	3,000
4 Collection, Onsite UV/Oxidation, Surface Discharge	3,280	170	3,710

Notes: (1) Based on 9 3/8% discount rate for a three year project duration.

(2) Alternative 2 based on 20 year project duration due to monitoring, not removal, of contamination.

TABLE 5-45. SUMMARY OF REMEDIAL ALTERNATIVE COSTS (PHASE III): SITE SP-7/10

Alternative	Capital Cost ($1000s)	Annual Cost ($1000s)	Present Worth[1] ($1000s)
1 No Action	0	0	0
2 Groundwater Monitoring, Groundwater Use Restrictions, Alternative Water Supply	27.5	28.9	285[2]
3 Collection, Onsite Air Stripping, Surface Discharge	514	86.6	732
6 Collection, Onsite UV/Oxidation, Surface Discharge	1,210	232	1,800

Notes: (1) Based on 9 3/8% discount rate for a three year project duration.

(2) Alternative 2 based on 20 year project duration due to monitoring, not removal, of contamination.

TABLE 5-46. SUMMARY OF REMEDIAL ALTERNATIVE COSTS (PHASE III): SITE SP-15

Alternative	Capital Cost ($1000s)	Annual Cost ($1000s)	Present Worth[1] ($1000s)
1 No Action	0	0	0
2 Groundwater Monitoring, Groundwater Use Restrictions, Alternative Water Supply	27.5	28.9	285[2]
3 Collection, Onsite Air Stripping, Surface Discharge	236	42.4	343
6 Collection, Onsite UV/Oxidation, Surface Discharge	552	77.0	745

Notes: (1) Based on 9 3/8% discount rate for a three year project duration.

(2) Alternative 2 based on 20 year project duration due to monitoring, not removal, of contamination.

samples. No additional costs are associated with providing an alternate water supply, as there is an existing alternate supply (a connection to Fort Richardson). The capital cost of this alternative is estimated at $27,500, the annual cost is $28,900, and the present worth is $285,000. The present worth for this alternative is based on a 20 year project duration, not three years as the other alternatives are. This is because the contamination is only monitored, not removed.

5.5.5.5.2 Alternative 3 - Collection, Onsite Air Stripping, Surface Water Discharge

The major capital costs involved with this alternative include installation of new groundwater monitoring and extraction wells, groundwater extraction and product recovery pumps, installation of water and product pipelines, a product storage tank and the associated containment berm, the air stripping treatment unit (Facino, Groundwater Technology, Inc., personal communication, 1989) and appurtenances, including a building to house the controls, blowers, and pumps. The equipment involved with product recovery is not required at Site SP-15. Also, site preparation, transportation of the equipment to Alaska, and set up of the treatment system are major capital costs. Site preparation includes power tap-in (including transformer) costs, clearing and grading of the site, construction of a concrete pad on which to place the stripping tower, and construction of an access road. Installation and transportation costs are estimated at 25 percent of the capital cost of the stripping unit. An additional cost, estimated at 20 percent of the stripping unit cost, is included for electrical and instrumentation needs at the site. Annual costs include air stripper O&M, power costs for extraction pumps, storage tank emptying and inspection, and groundwater and surface water discharge monitoring. Air stripper O&M costs are based on power costs for pumps and blowers, a biannual acid cleaning of the

tower and packing, and 2 man-hours per week for inspection. Monitoring costs are based on quarterly sampling of the new and existing groundwater monitoring wells and monthly sampling of the treatment plant discharge. Samples will be analyzed for VOCs and TPH.

5.5.5.5.3 Alternative 6 - Collection, Onsite UV/Oxidation, Surface Discharge

Major capital costs for this alternative are very similar to those described for Alternative 3, the only differences being in the unit costs for the treatment equipment and installation. In this alternative, installation is estimated at 20 percent of the capital cost of the treatment unit and is considered to include electrical and instrumentation costs. The lower percentage for installation of the unit is based on the higher cost for the treatment unit itself. Annual costs will also be very similar to Alternative 3 in structure; have the O&M unit costs will vary. The UV/Oxidation process generally requires more power, inspection, and maintenance to operate than the air stripping process. Unit costs for the capital and O&M costs for the treatment unit were provided by equipment vendors.

5.5.5.6 Cost Sensitivity Analysis

The cost sensitivity analysis addresses factors that may substantially affect the overall cost of the alternatives. Factors included in the sensitivity analysis are discussed below.

- Discount Rate - A discount rate of 9.375 percent, the 1989 discount rate (as dictated by the U.S. Treasury Department using the guidelines in 39 Federal Register 29242), was used to calculate the present worth of each alternative. The discount rate, however, could vary. Tables 5-47 to 5-51 show effect on the present worth of each alternative with a discount rate varying from 5 to 15 percent.

TABLE 5-47. SENSITIVITY OF ALTERNATIVES TO PROJECT DURATION AND DISCOUNT RATE: SITE D-16

	Present Worth ($1000s)						
	Project Life [1]				Discount Rate [2]		
Alternative	1 Year	3 Years	8 Years	20 Years	5%	9 3/8%	15%
1 No Action	0	0	0	0	0	0	0
7 Containment by Surface Capping	848	860	883	909	936 [3]	909 [3]	889 [3]
9 Excavation, Offsite Sanitary Landfill Disposal	1,940	1,950	1,980	2,020	1,950	1,950	1,950
10 Excavation, Offsite RCRA-Permitted Landfill Disposal	8,780	8,790	8,820	8,840	8,780	8,790	8,790

Notes: (1) Based on 9 3/8% discount rate.

(2) Based on 3 year project duration.

(3) Alternative 7 based on 20 year project duration due to containment, not removal, of contamination.

TABLE 5-48. SENSITIVITY OF ALTERNATIVES TO PROJECT DURATION AND DISCOUNT RATE: SITE IS-1

	Present Worth ($1000s)						
	Project Life [1]				Discount Rate [2]		
Alternative	1.8 Years	3 Years	5.5 Years	20 Years	5%	9 3/8%	15%
1 No Action	0	0	0	0	0	0	0
2 Groundwater Monitoring, Groundwater Use Restrictions, Alternate Water Supply	54.0	100	139	285	386[3]	285[3]	209[3]
3 Collection, Onsite Air Stripping, Surface Discharge	485	548	672	1,000	563	548	532
6 Collection, Onsite UV/Oxidation, Surface Discharge	1,280	1,530	2,000	3,280	1,580	1,530	1,460

Notes: (1) Based on 9 3/8% discount rate.

(2) Based on 3 year project duration.

(3) Alternative 2 based on 20 year project duration due to monitoring, not removal, of contamination.

TABLE 5-49. SENSITIVITY OF ALTERNATIVES TO PROJECT DURATION AND DISCOUNT RATE: SITE SP-5/5A

	Present Worth ($1000s)						
	Project Life (1)				Discount Rate (2)		
Alternative	1 Year	3 Years	8 Years	20 Years	5%	9 3/8%	15%
1 No Action	0	0	0	0	0	0	0
2 Groundwater Monitoring, Groundwater Use Restrictions, Alternate Water Supply	54.0	100	185	285	386 (3)	285 (3)	209 (3)
3 Collection, Onsite Air Stripping, Surface Discharge	2,890	3,000	3,210	3,440	3,020	3,000	2,990
6 Collection, Onsite UV/Oxidation, Surface Discharge	3,440	3,710	4,210	4,790	3,740	3,710	3,670

Notes: (1) Based on 9 3/8% discount rate.

(2) Based on 3 year project duration.

(3) Alternative 2 based on 20 year project duration due to monitoring, not removal, of contamination.

TABLE 5-50. SENSITIVITY OF ALTERNATIVES TO PROJECT DURATION AND DISCOUNT RATE: SITE SP-7/10

	Present Worth ($1000s)						
	Project Life (1)				Discount Rate (2)		
Alternative	2.7 Years	3 Years	8.2 Years	20 Years	5%	9 3/8%	15%
1 No Action	0	0	0	0	0	0	0
2 Groundwater Monitoring, Groundwater Use Restrictions, Alternate Water Supply	78.1	100	185	285	386 (3)	285 (3)	209 (3)
3 Collection, Onsite Air Stripping, Surface Discharge	718	732	1,010	1,300	750	732	712
6 Collection, Onsite UV/Oxidation, Surface Discharge	1,760	1,800	2,540	3,310	1,850	1,800	1,750

Notes: (1) Based on 9 3/8% discount rate.

(2) Based on 3 year project duration.

(3) Alternative 2 based on 20 year project duration due to monitoring, not removal, of contamination.

TABLE 5-51. SENSITIVITY OF ALTERNATIVES TO PROJECT DURATION AND DISCOUNT RATE: SITE SP-15

Alternative	Present Worth ($1000s): Project Life (1)				Discount Rate (2)		
	2.3 Years	3 Years	7 Years	20 Years	5%	9 3/8%	15%
1 No Action	0	0	0	0	0	0	0
2 Groundwater Monitoring, Groundwater Use Restrictions, Alternate Water Supply	78.2	100	171	285	386 (3)	285 (3)	209 (3)
3 Collection, Onsite Air Stripping, Surface Discharge	322	343	453	619	352	343	333
6 Collection, Onsite UV/Oxidation, Surface Discharge	708	745	946	1,240	762	745	728

Notes: (1) Based on 9 3/8% discount rate.

(2) Based on 3 year project duration.

(3) Alternative 2 based on 20 year project duration due to monitoring, not removal, of contamination.

- Project Duration - The duration of each project was estimated at 3 years for each alternative pertaining to contamination removal. For Alternatives 2 and 7, which do not remove the contamination, the project duration was estimated at 20 years. The project life could prove to be much longer or shorter. Therefore, the project life was varied from 1 to 20 years for the sensitivity analysis. Project lives used in addition to 3 years are the minimum and maximum estimated times, required to reach target cleanup levels as shown in Table 5-28. A 20 year project duration is also included to show the effect on the cost should the remedial action take much longer to reach target cleanup levels than anticipated. The effect on the present worth of each alternative can also be seen in Tables 5-47 to 5-51.

- Contaminated Soil Disposal - For Alternatives 3 and 6 at Site SP-5/5A, it was assumed that the contaminated soil removed to construct the groundwater collection trench must be disposed of in a RCRA-permitted landfill. If it is determined that the soil can be disposed of at the local sanitary landfill, it would result in the present worth of both Alternatives 3 and 6 at Site SP-5/5A decreasing by $1.3 million, or a decrease of 44 and 35 percent, respectively.

- Site Conditions - The 6 sites that pertain to remediation of contaminated groundwater (IS-1, SP-5/5A, SP-7/10, and SP-15) all have similar types of contamination (predominately BETX compounds). However, each site has different estimated groundwater collection rates and contaminant concentrations. It is assumed that a sufficient range of remedial action costs has been presented to cover credible deviations from estimated site conditions. If the estimated groundwater

collection rate or contaminant concentration at the site proves to be different than anticipated for this FS, conditions at other sites can be compared to the new site conditions and a new budgetary level cost can be estimated. As discussed earlier, factors such as the final scope of the project and competitive market conditions must be carefully reviewed before estimating final budgets.

VI. RECOMMENDATIONS

A prioritization of sites was made in Section IV. Eight sites were recommended for no further action. Seventeen sites were recommended for additional IRP effort and were prioritized for further investigation: 5 sites were given a high priority, 11 sites were given a medium priority, and 1 site was given a low priority. Seven sites were included in the Feasibility Study and also need further investigation. Table 6-1 identifies the prioritized sites as they fit into each category listed above.

This section presents recommendations for the direction and approach for future IRP efforts. The recommendations will address each site individually and categorize them in the following manner:

- Category 1 - Sites where no further IRP action, including remedial action, is required. These sites have existing data that is sufficient to determine no significant impact to human health or the environment.

- Category 2 - Sites requiring additional IRP effort to:

  - Determine the mobility, toxicity and volume (MTV) of detected contaminants.

  - Evaluate human health and environmental risks associated with each contaminant.

  - Conduct the detailed evaluation of remedial alternatives.

- Category 3 - Sites where the Feasibility Study process has been completed and a remedial alternative selected.

TABLE 6-1. CATEGORIZATION OF SITES

Category 1 Sites	Category 2 Sites			Category 3 Sites
	Sites Requiring Additional IRP Effort			
No Further Action	High Priority	Medium Priority	Low Priority	Feasibility Study*
D-3	D-5	D-17	D-15	D-16
IS-2	D-7	IS-3	SP-13	IS-1
IS-5	D-13	IS-4		SP-5/5A
SP-12	SP-1	IS-6		SP-7/10
SP-14	NS-2	IS-7		SP-15
NS-3		IS-8		
S-6		SP-2/6		
		SP-4		
		SP-11		
		NS-1		

*These sites also need further investigation.

6.1 CATEGORY 1

Category 1 contains 7 sites where no further IRP effort or remedial action is required. Each site has been individually examined and evaluated based on the data collected and found to have no significant impact to human health or the environment. A Technical Document to Support No Further Action will be developed for each site in Category 1.

6.1.1 Recommendations for Site D-3, Landfill

Site D-3 is a landfill of approximately 15 acres and was operated from 1943 to 1957. The site was primarily used for the disposal of general refuse, construction rubble, small quantities of shop wastes and spent ammunition. The landfill is covered with gravelly clay and heavy vegetation (Engineering-Science, 1983).

The site has been adequately characterized to determine no significant impact to human health or environment will occur. The site was sampled and analyzed using a soil gas survey, installation of 3 monitoring wells and 1 test boring, and analysis of 3 water samples and 8 soil samples. During the soil gas survey a reading of 15.6 ppm toluene was recorded at 1 location, with other readings ranging from nondetectable to 2.67 ppm toluene. Benzene was detected in 2 soil gas survey samples at levels of 0.06 ppm and trace. Xylene levels ranged from nondetectable to 6.7 ppm. Unidentified organics levels ranged from nondetectable to 0.63 ppm in benzene equivalents. Results of the soil gas survey were used to locate the monitoring wells and test boring; however, the BETX compounds were not detected in any of the soil or water samples. Organic contaminants were detected in 1 soil sample: 1.4 mg/kg of 4-methylphenol was detected at a depth of 30 feet in well D3-02. No soil soil cleanup levels, based on human

health risks, were exceeded. Water samples at Site D-3 met the State of Alaska Primary Drinking Water Standards for organic compounds and metals. Only dissolved manganese exceeded the State of Alaska and EPA Secondary Drinking Water Standards. These Standards serve only as guidelines for the aesthetic quality of drinking water. The levels of manganese fall within the range of background concentrations at Elmendorf AFB; although they are environmentally persistent, the metals are not considered to be highly toxic.

Receptors and pathways of exposure are present, but the duration, frequency and level of exposure are not expected to be significant to cause adverse health effects. Site D-3 is assigned no further action.

6.1.2 Recommendations for Site IS-2, Hangar Floor Drains

Site IS-2 is a floor drain at Hangar 11 that is used for aircraft maintenance. Approximately 100 gallons per month of the solvent PD-680 is reportedly washed into building floor drains. These floor drains incorporate dry wells as part of the floor drain system (Engineering-Science, 1983).

The site has been adequately characterized to determine that no significant impact to human health or the environment will occur. The site was investigated using geophysical techniques to locate drywells and a test boring was drilled and completed as a monitoring well. During the placement of the well the following observations were made. A fuel tank vent on the east side of Hangar 11 had an active steady, slow drip of diesel fuel. The ground below the leak was stained and there was an odor of diesel fuel. An HNu meter detected organic vapors during the placement of the well: At 5 feet an HNu reading of 0.2 ppm, at 10 feet 0.5 ppm, and at 20 feet 2.0 ppm was recorded. Two soil samples and a water sample were analyzed. Total mercury was detected in a water sample taken from well IS2-01 at a concentration

of 0.0032 mg/L which exceeds the State of Alaska and EPA Primary Drinking Water Standards. This concentration is outside the range of concentrations detected in the background wells. Dissolved mercury was not detected at Site IS-2. Other metal concentrations in the soil and groundwater samples from this site were generally similar to the basewide hydrogeology wells. TPH was detected at a concentration of 0.7 mg/L in a water sample from Site IS-2; however, since the sample did not exhibit a petroleum odor or sheen, the State of Alaska Drinking Water Standard for petroleum products was not exceeded.

Shallow groundwater is not utilized in the vicinity of Site IS-2, nor is it likely to be used in the future. Receptors and pathways are present, but the duration, frequency and level of exposure is not expected to be significant to cause adverse health effects. Site IS-2 is assigned no further action.

6.1.3 Recommendations for Site IS-5, Hangar Floor Drains

Site IS-5 is located near Building 43-410, which is a garage complex used for storage and refueling operations. The building contains a washrack for ground equipment. It has been reported that approximately 55 gallons per month of solvent PD-680 is used in the washrack (Engineering-Science, 1983). Originally, the floor drains discharged to dry wells. Currently, floor drains are connected to septic tank and leach fields at the south side of Building 43-410. (Personal Communications, Major T.A. Ritz).

The site has been adequately characterized to determine no significant impact to human health or environment will occur. The site was sampled and analyzed utilizing a test boring that was completed as a monitoring well. No evidence of contamination was observed during the drilling of the well. Two soil samples and a water sample were analyzed. Bis(2-ethylhexyl) phthalate was detected at a concentration

of 0.62 mg/kg in a soil sample taken at a depth of 5 feet. No soil cleanup levels were exceeded. Total petroleum hydrocarbons were detected at a concentration of 0.6 mg/L in a water sample from Site IS-5; however, since the sample did not exhibit a petroleum odor or sheen, the State of Alaska Drinking Water Standard for petroleum products were not exceeded. Metal concentrations in the soil and groundwater samples from this site were generally similar to the basewide hydrogeology wells.

Shallow groundwater is not utilized in the vicinity of Site IS-5, nor is it likely to be used in the future. Receptors and pathways are present, but the duration, frequency and level of exposure is not expected to be significant to cause adverse health effects. Site IS-5 is assigned no further action.

6.1.4 Recommendations for Site SP-12, JP-4 Fuel Line Leak

Site SP-12 is located where an underground fuel line leak of approximately 1,000 gallons of JP-4 fuel occurred in 1971 (Engineering Science, 1983). Most of the spilled fuel was recovered and the contaminated soil was removed.

The site has been adequately characterized to determine no significant impact to human health or environment will occur. The site was investigated by sampling existing groundwater monitoring wells, GW-3A and W-9. Two water samples were analyzed for total dissolved solids, purgeable aromatics, and TPH. Water samples taken from each well contained 1.0 mg/L of TPH; however, since the samples did not exhibit a petroleum odor or sheen, the State of Alaska Drinking Water Standards for petroleum products were not exceeded. No purgeable aromatics were detected.

Water samples from the site met State of Alaska Primary Drinking Water Standards. Receptors and pathways of exposure are present, but the duration, frequency, and level of exposure is not expected to be significant to cause adverse health effects. Site SP-12 is assigned no further action.

6.1.5 Recommendations for Site SP-14, MOGAS spill

Site SP-14 is located where a 1500 gallon motor gasoline (MOGAS) spill that occurred in 1965. The fuel which was not recovered seeped into the porous gravel of the area (Engineering-Science, 1983).

The site has been adequately characterized to determine no significant impact to human health or environment will occur. The site was evaluated using a soil gas survey, installation of 2 test borings which were completed as monitoring wells, and analysis of groundwater samples collected from 2 existing monitoring wells, GW-7A and W-17. Four soil samples and 4 water samples were analyzed. During the installation of the monitoring well SP14-01, an HNu meter detected organic vapors of 2.5 ppm on a soil sample taken at a depth of 5 feet, 15 ppm on a soil sample taken at a depth of 10 feet, and 25 ppm with a petroleum odor on a soil sample taken at a depth of 30 feet. No organic vapors were detected on soil samples from well SP14-02. During the soil gas survey, a reading of 4.19 ppm toluene was recorded at 1 location, with other readings at the site ranging from nondetectable to 1.86 ppm toluene. Benzene was detected in 7 soil gas survey samples at levels from 0.09 ppm to 3.71 ppm. Xylene levels ranged from nondetectable to 0.71 ppm and unidentified organic levels ranged from nondetectable to 0.79 ppm in benzene equivalents. Results of the soil gas survey were used to locate the monitoring wells; however, the BETX compounds were not detected in any of the soil or water samples. TPH (well SP14-01) and 2-butanone (well SP14-02) were

detected at concentrations of 88 mg/kg and 0.25 mg/kg respectively in soil samples taken at depths of 30 feet. No soil cleanup levels were exceeded.

Dissolved lead was detected in water samples taken from 3 of the 4 wells at Site SP-14 at concentrations of 0.052 mg/L, 0.065 mg/L, and 0.066 mg/L which exceed the State of Alaska and EPA Primary Drinking Water Standards of 0.05 mg/L. In the fourth well, upgradient well W-17, the concentration was 0.003 mg/L. Lead was not detected in the soil. Water samples collected in 1986 from well GW-7A detected TPH of 3.5 mg/L (Dames and Moore, 1987). During the 1988 field investigation program, TPH were detected only in well W-17 at a concentration of 0.8 mg/L. However, since the sample did not exhibit petroleum odor or sheen, the State of Alaska Drinking Water Standard for petroleum hydrocarbons was not exceeded.

Water samples at Site SP-14 exceeded the State of Alaska and EPA Primary Drinking Water Standards for lead. However, the standards are only slightly exceeded and the shallow groundwater is not utilized in the vicinity of Site SP-14, nor is it likely to be used in the future. Receptors and pathways are present, but the duration, frequency and level of exposure is not expected to be significant to cause adverse health effects. Site SP-14 is assigned no further action.

6.1.6 Recommendation for Site S-6, PCB Transformer Storage Area

Site S-6 is an area where a large number of transformers were stored on the ground during the 1970's. Although no significant transformer spills have been documented, some leakage may have occurred. Groundwater was not sampled at this site, but is at a depth of approximately 10 feet. Based on regional trends, groundwater flows to the south.

The site has been adequately characterized to determine that no significant impact to human health or the environment will occur. Soil samples were collected from 6 shallow boreholes and were analyzed for organochlorine pesticides and PCBs. Aroclor 1260 was the only contaminant detected in soil samples from Site S-6. This compound was detected in a surface sample from boring S6-02 at a concentration of 1.8 mg/kg. The method detection limit for Aroclor 1260 is 1.6 mg/kg. State of Alaska regulation is 10 mg/kg for soil contaminated with Aroclor 1260.

It is highly unlikely that groundwater at Site S-6 has been contaminated based on current data and the fact that PCBs are not readily soluble and relatively immobile. The 1 borehole where PCBs were detected was at a much lower concentration than the regulatory cleanup level. Receptors and pathways of exposure are present, but the duration, frequency, and level of exposure are not expected to be significant to cause adverse health impacts. Site S-6 is assigned no further action.

6.1.7 Recommendations for Site NS-3, Golf Course Seep

Site NS-3 is located where, previous to the RI/FS field investigations, fuel of unknown origin appeared on the ground immediately north of the Golf Pro Shop. The fuel flowed into a drainage ditch that parallels Post Road. A records search did not find any dry wells on the site; however, a buried POL line belonging to the U.S. Army traverses the area. A buried U.S. Air Force JP-4 pipeline parallels Second Street at the north end of the site. This pipeline previously had minor spills according to Air Force liquid fuels maintenance personnel.

The site has been adequately characterized to determine no significant impact to human health or environment will occur. The site was

evaluated using a soil gas survey and installation of 6 test borings, 3 of which were completed as monitoring wells. Twelve soil samples and 3 water samples were analyzed. During the installation of the borings NS3-01, NS3-04, and NS3-05 and wells NS3-02 and NS3-03, no evidence of contamination such as stains, odor or HNu readings was observed. An HNu reading of 1 ppm was recorded on a soil sample taken at a depth of 25 feet in well NS3-06. During the soil gas survey, a reading of 6340 ppm benzene was recorded at 1 location, with other readings on the site ranging from nondetectable to 15.85 ppm benzene. Toluene was detected at 23 out of 26 locations with readings ranging from trace to 7.53 ppm. Xylene was detected at 22 out of 26 locations with 11 readings at trace levels and 1 reading as high as 6.26 ppm. Unidentified organics levels ranged from nondetectable to 3.13 ppm in benzene equivalents. Organic contaminants were detected in only 1 soil boring. TPH were detected in soil samples taken from well NS3-06 at concentrations up to 56 mg/kg. The cleanup levels suggested by the interim ADEC guidelines were not exceeded.

Water samples were analyzed for purgeable hydrocarbons and aromatics, extractable priority pollutants and total dissolved solids. Trichloroethene was detected in water samples taken from well NS3-02 at a concentration of 1.2 ug/L which is below the State of Alaska Primary Water Quality Standard of 5.0 ug/L. TPH were detected in NS3-02 and NS3-03 at levels of 2.0 mg/L and 0.7 mg/L, respectively. These concentrations are in compliance with State of Alaska standards for TPH since no petroleum odor or sheen were detected during sampling. Water samples at Site NS-3 met the State of Alaska and EPA Primary Drinking Water Standards.

Receptors and pathways of exposure are present, but the duration and frequency of exposure was not expected to have caused any adverse health effects. Site NS-3 is assigned no further action.

6.2 CATEGORY 2

Category 2 contains 17 sites which require additional IRP effort. These sites have been prioritized for further investigation: 5 sites were given high priority, 10 sites were given medium priority, and 2 sites were given low priority. The additional data required to complete the characterization of the site with regard to extent and type of contamination are presented for each Category 2 site. The sites given a high priority for further investigation are discussed first, followed by medium and low priority sites.

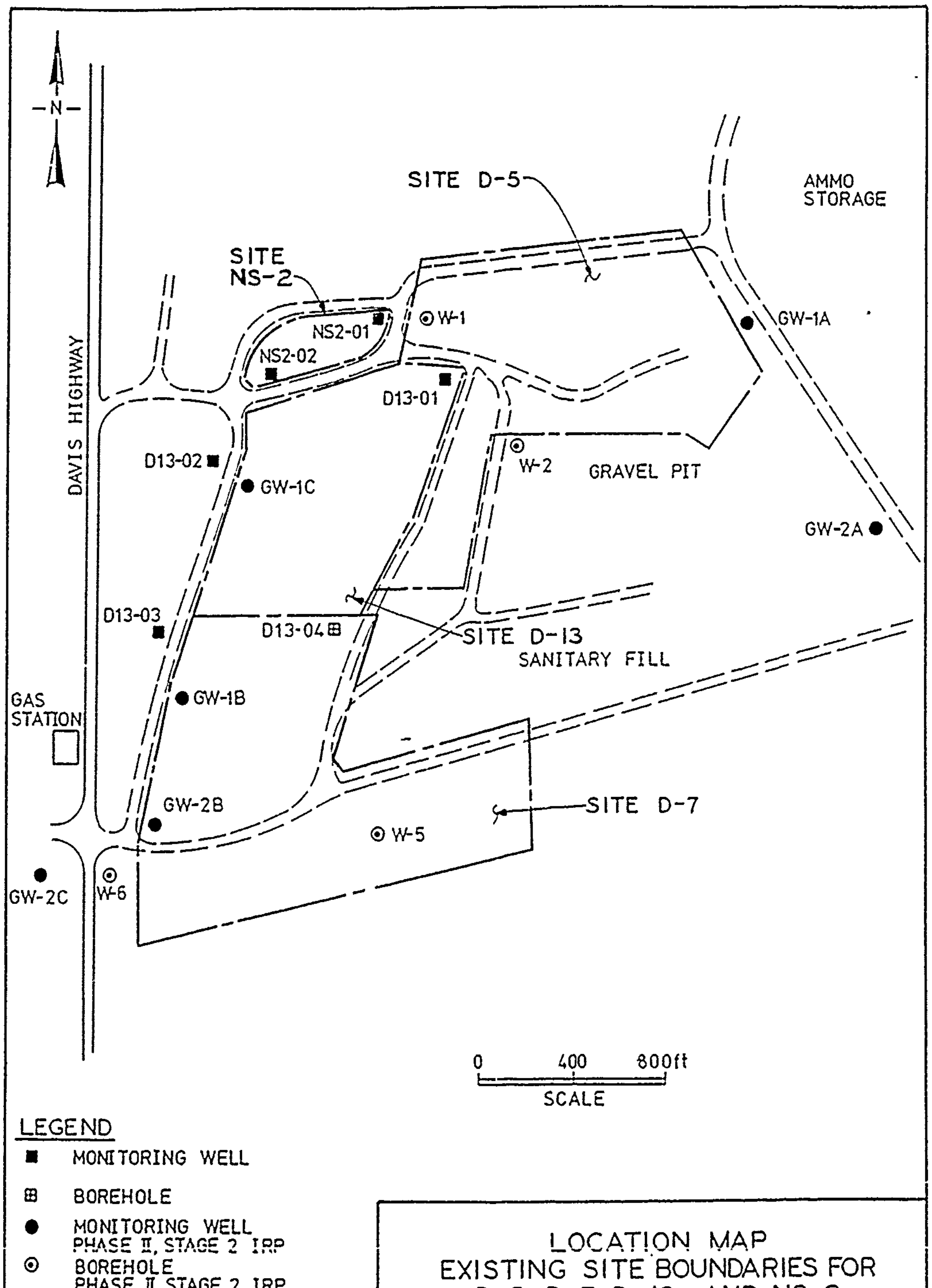
6.2.1 Recommendations for Sites D-5, D-7, D-13, NS-2

It is recommended that sites D-5, D-7, D-13 and NS-2, be combined due to their geographical proximity and the similarity of the contaminants found on these sites. (Figures 6-1 and 6-2) This new site would be assigned a high priority for further investigation due to contaminant levels exceeding State of Alaska Primary Drinking Water Standards and the evidence of offsite migration.

The following are descriptions of the adjoining sites:

Site D-5 is a landfill of approximately 17 acres and was operated from 1951 to 1973 (Engineering-Science, 1983). The site was primarily used for the disposal of general refuse, scrap metal, spent chemicals, and construction rubble. A portion of this site is presently being used for a gravel extraction operation.

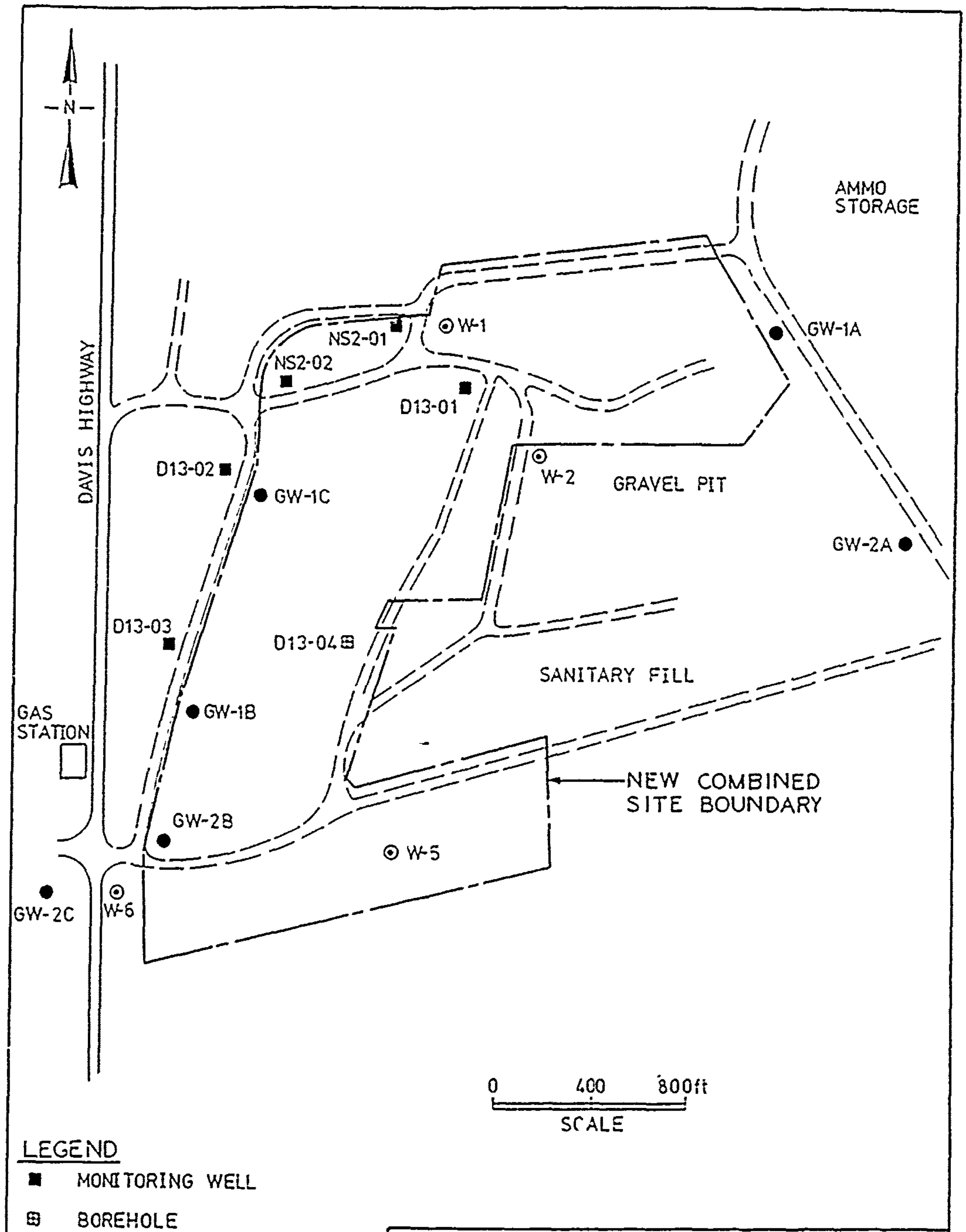
Site D-7 is an active sanitary landfill of 35 acres which has been used since 1965 for the disposal of Base-generated refuse, scrap metal, construction rubble, drums of asphalt and empty pesticide containers (Engineering-Science, 1983). A section in the active area of the landfill is used for the disposal of asbestos waste generated on Elmendorf AFB.



LOCATION MAP
EXISTING SITE BOUNDARIES FOR
D-5, D-7, D-13 AND NS-2

IRP Stage 3 RI/FS
Elmendorf AFB, AK

Figure
6-1



NEW COMBINED SITE BOUNDARY
SITES D-5, D-7, D-13 AND NS-2

IRP Stage 3 RI/FS
Elmendorf AFB, AK

Figure 6-2

Site D-13 is an old gravel pit which was used as a disposal site from 1967 to 1971. The 2 acre site was used to dispose of empty drums, metal piping, drums of asphalt, and small quantities of quicklime (Engineering-Science, 1983).

Site NS-2 has drums containing various kinds of materials stored onsite and some surface staining of the soil has resulted (Harding Lawson Associates, 1988).

The primary wastes detected in samples collected at the site are organic compounds and metals. Groundwater samples collected from 15 monitoring wells were contaminated at levels above State of Alaska Standards for several suspected or confirmed carcinogens. Several compounds, including trichloroethane, detected in 1986 samples were also detected in 1988 samples, but at higher concentrations. This indicates that the contamination is environmentally persistent. There is evidence that offsite migration is occurring. The scope of this study does not allow an accurate estimate of the volume of contamination released since exact types and quantities of materials buried at the site were never recorded. Receptors are present, but pathways of exposure are not highly significant. Duration and frequency of exposure is not expected to be high, but the presence of carcinogenic compounds at levels exceeding State of Alaska Standards indicates that further investigation will be required at this site.

Solute transport models would be applicable at this site, but more information is needed from wells located downgradient. Wells installed to the north and northwest of the site and additional hydrogeologic data would provide useful information and more accurate solute transport models. The results of this modeling would help determine the mobility, toxicity and volume of the detected

contaminants. Further evaluation of the potential risk of contamination for downgradient water supplies and surface water could also be assessed.

Further investigation at this site should include the installation of 7 additional monitoring wells to aid in the determination of the northern, western, and vertical extent of the contaminant plume and the MTV of detected contaminants. Soil samples from the new borings and groundwater samples from all monitoring wells should be analyzed for TPH, VOCs, extractable priority pollutants, PCBs and pesticides, common anions, and metals including lead. The drinking water well (Base Well 42), located 5200 feet downgradient from the site, should be sampled and analyzed to ensure that no contamination has occurred to the confined aquifer. In addition, expansion of the gravel pit adjacent to the sites should be halted. Gravel pit operations have already destroyed wells D13-02, D13-03, GW-1C, and GW-1B. Also, by destroying the well head and leaving the casing in place, there is now a direct pathway by which the aquifer may become contaminated by surface activities.

6.2.2 <u>Recommendations for Site SP-1, Diesel Fuel Line Leak.</u>

Site SP-1 is the location of a diesel fuel line leak that occurred between 1956 and 1958 (Engineering-Science, 1983) and is adjacent to 3 underground POL lines. Thousands of gallons of diesel fuel were recovered at this location during the late 1950's, but an unknown amount may have remained below ground. This site is assigned high priority due to contaminants exceeding the State of Alaska Water Quality Standards and the evidence of offsite migration.

Groundwater from 2 monitoring wells was sampled and analyzed for TPH, purgeable aromatics, and extractable priority pollutants. The primary wastes at the site are VOCs; specifically, benzene, ethylbenzene,

toluene, and xylenes (BETX). TPH was also detected. Groundwater samples were contaminated at levels above the State of Alaska and EPA regulations for benzene and State of Alaska regulations for TPH. TPH was also detected (400 mg/kg) in a soil sample from boring SP1-02. Contamination detected by the soil gas survey and in wells SP1-01 and SP1-02 indicate that offsite migration is occurring. Results of the soil gas survey indicated that contamination encompasses about 5 acres, covering areas to the south, east and west of the presumed leak from underground POL lines. The potential for off-Base migration is high. Groundwater flow is to the south-southeast and the nearest Base boundary in that direction is approximately 200 feet. Ship Creek is less than 500 feet to the southeast. Toluene and xylenes were pervasive, especially at the base of the bluff north of the railroad. A small pond located immediately to the west of well SP1-01 had a visible sheen in the water and a petroleum odor. This water was not sampled.

The scope of this study does not allow an accurate estimate of the volume or extent of contamination at this site. Receptors and pathways are present and a possible threat to human health exists. Duration and frequency of exposure is not expected to be high, but the presence of carcinogenic compounds at levels exceeding State of Alaska Standards indicates that further investigation will be required at this site.

Solute transport models are applicable at this site, but more information is needed from wells located downgradient. Wells installed to the south and southeast of the site may provide additional hydrologic data and data on the spatial and temporal variations in contaminant concentrations and allow the formation of more accurate solute transport models. The results of this modeling would help determine the mobility, toxicity and volume (MTV) of the detected contaminants. Further evaluation of the potential risk of

contamination for downgradient water supplies and surface water could also be assessed.

Further investigation at this site should include a soil gas survey and use of groundwater field screening probes to the south of the railroad tracks and north of the POL pipelines. The survey will better define the plume dimensions and will aid in the selection of additional monitoring well locations. Five monitoring wells should be added in order to determine the contaminant plume boundary and the mobility, toxicity, and volume of the detected contaminants. Additional sampling and analysis of the existing wells is also recommended. In addition, water samples should be collected from the contaminated pond and from Ship Creek at a point immediately downgradient from the site. All water samples should be analyzed for TPH, VOCs and purgeable halocarbons. Soil samples from the new monitoring wells should be sampled for TPH and VOCs.

6.2.3 Recommendations for Site D-17, Shop Waste Disposal

Site D-17 covers an area of approximately 12.5 acres. A natural trench in the vicinity of the site was used during the 1950's and 1960's as a disposal area for waste solvents, paint thinners, and other liquids generated in shop operations (Engineering-Science, 1983). The waste materials were poured directly onto the permeable soil. The area has been covered with soil and the exact location of the trench is unknown. The site has been evaluated through 2 existing groundwater monitoring wells and 6, 5-foot borings. A soil gas survey delineated the boundaries of the site. The site is assigned medium priority for further investigation due to contaminant levels exceeding the State of Alaska Primary Water Quality Regulations and the evidence of offsite migration.

The primary contaminants detected in the soil and groundwater samples taken at the site are VOCs. Contaminants were concentrated in

boreholes and wells situated to the east. Benzene, 1,2-dichloroethane, and trichloroethene were detected in water samples. Trichloroethene levels exceeded the MCL. Both wells, W-11 and W-13, had TPH levels of 2.0 mg/L. Benzene and trichloroethene were detected in Well W-11 at concentrations of 1.3 ug/L and 45 ug/L respectively. A 1986 sample from this well contained 47 ug/L trichloroethene. Trichloroethene and 1,2-dichloroethane were detected in Well W-13 at concentrations of 5.4 ug/L and 0.54 ug/L respectively. A 1986 sample from this well contained 5.2 ug/L of tricholoroethene. Metal concentrations in the soil and groundwater from this site were generally similar to the basewide hydrogeology wells. Dissolved barium, arsenic, and manganese were detected in the groundwater at concentrations greater than the basewide hydrogeology wells. However, the dissolved concentrations did not exceed primary MCLs. Manganese does exceed the secondary MCL.

TPH was detected in soil samples from borings on the eastern half of the site, D17-01, D17-02, D17-03, and D17-04, at concentrations ranging from 67 mg/kg to 170 mg/kg. The organochlorine pesticide 4,4-DDT was detected in all 6 boreholes at concentrations ranging from 0.026 mg/kg to 0.11 mg/kg. The pesticide 4,4-DDD was detected in soil samples taken from borehole D17-02 at concentrations of 0.11 mg/kg at a depth of 1 foot and 0.049 mg/kg at a depth of 4 feet. The following polycyclic aromatic hydrocarbons (PAH) were detected only in the surface sample from borehole D17-04 benzo(a)anthracene (1.1 mg/kg), benzo(a)pyrene (0.92 mg/kg), benzo(b)fluoranthene (1.1 mg/kg), benzo(k)fluoranthene (1.1 mg/kg), and chrysene (1.1 mg/kg). This same soil sample contained 3.4 mg/kg of fluoranthene, 1.2 mg/kg of phenanthrene and 2.6 mg/kg of pyrene.

The scope of this study does not allow an accurate estimate of the volume of contamination released since the actual contaminant source location is not known. Contamination in offsite and downgradient wells indicates the existence of contaminant migration. Receptors are

present, but pathways of contamination exposure through the groundwater are unknown. The nearest drinking water well is nearly 1 mile distant and has not shown to be contaminated. However, the direction and size of the contaminant plume and other exposure pathways is unknown. Duration and frequency of exposure is not expected to be high, but the presence of carcinogenic compounds at levels exceeding State of Alaska Primary Drinking Water Standards indicates that further investigation at this site is required.

Solute transport models may be important at this site. Wells installed to the south of the site may provide additional hydrogeologic data and allow the formation of more accurate solute transport models. The results of this modeling would help to determine the mobility, toxicity and volume of the detected contaminants. Further evaluation of the potential risk for downgradient water supplies and surface water could also be assessed.

Further investigation at this site should include a soil gas survey to determine the south and southeast limits of contamination and aid in the selection of additional monitoring well locations. Seven additional downgradient wells are proposed. The new wells should be located as follows: 1 well placed offsite and upgradient of boring D17-06, and 6 wells placed outside the southern and eastern boundaries of the site. Soil samples from the proposed wells and water samples from both the proposed and previously installed wells should be sampled and analyzed for VOCs, TPH, semi-volatile organic compounds, and metals including lead. A slug test should be conducted in 1 of the 7 new monitoring wells to determine the hydraulic conductivity of the surficial aquifer. The results of these tests should aid in identifying the plume dimensions and flow rates along the downgradient plume margin.

6.2.4 Recommendations for Site IS-3, Hangar Floor Drains

Site IS-3 is located near Hangar 14, which is used for helicopter maintenance and contains a helicopter washrack. Reportedly, about 55 gallons per month of PD-680 is used in wash operations; some of this solvent is washed into floor drains which incorporate dry wells as part of the floor drain system (Engineering-Science, 1983). Cherry Hill Ditch is located approximately 2 miles to the southwest of the site. Runway drains adjacent to Site IS-3 empty into the ditch. Any contamination entering the drains would reach the ditch rapidly. This site is assigned medium priority for further investigation due to contaminant levels exceeding the State of Alaska Primary Water Quality Standards.

Soil and groundwater taken from a borehole, completed as monitoring well IS3-01, were analyzed for VOCs, TPH, organochloride pesticies, PCBs, and metals. The primary contaminants detected in the groundwater were pesticides and TPH. Groundwater samples were contaminated at levels above the EPA National Ambient Water Quality Criteria (NAWQC) Standard for the pesticide alpha-BHC (0.013 ug/L). TPH (1.3 mg/L) were detected in well IS3-01. Since the water sample did not have a petroleum odor or sheen, State of Alaska Primary Drinking Water Standards were not exceeded. Metal concentrations in the soil and groundwater samples from this site were generally similar to the basewide hydrogeology wells. The water sample did exceed Secondary Drinking Water Standards for manganese.

The scope of this study does not allow an accurate estimate of the volume of contamination released. VOCs and pesticides may be migrating in the groundwater, as contamination by TPH was detected downgradient at Sites IS-1, IS-2, and IS-4. However, each of these sites has its own source of contamination, which may be the sole source of organic contaminants at each site. Receptors and pathways are present, but contaminant release and migration characteristics

have not been identified since only 1 well was sampled and installed at the site.

Solute transport models may be important at Site IS-3. Wells installed to the south and southwest of the site may provide additional hydrogeological data and allow the formation of more accurate solute transport models. The results of this modeling would help to determine the mobility, toxicity and volume of the detected contaminants. Further evaluation of the potential risk for downgradient water supplies and surface water could also be assessed.

Further investigation at this site should include the installation of 2 additional downgradient monitoring wells and 1 upgradient well. Soil samples from the proposed wells and water samples from both the proposed and previously installed wells should be sampled and analyzed for VOCs, TPH, organochlorine pesticides and PCBs, and metals including lead and mercury. A slug test should be conducted in 1 of the new monitoring wells to determine the hydraulic conductivity of the surficial aquifer.

6.2.5 Recommendations for Site IS-4, Hangar Floor Drain

Site IS-4 is located near Hangar 8, which is used for aircraft cleaning and painting. It is possible that floor drains in the building have received rinse water and minor spillage from these operations. Dry wells used to be incorporated as part of the floor drain system. (Engineering-Science, 1983). Currently, floor drains discharge to an oil/water separator and then to the storm drain. Cherry Hill Ditch is located approximately 5000 feet southwest of the site. Runway drains adjacent to Site IS-4 empty into the ditch, which empties into the Knik Arm. This site is assigned medium priority for further investigation due to contaminant levels exceeding the State of Alaska Primary Water Quality Regulations and the potential for offsite migration.

A borehole, completed as monitoring well IS4-01, was sampled; the soil and groundwater were tested for VOCs, TPH, organochloride pesticides, PCB's and metals. The primary contaminants in the soils and groundwater are pesticides and TPH. The pesticide alpha-BHC was detected in groundwater samples from well IS4-01 at a concentrations of 2.3 ug/L. This level exceeds EPA NAWQC Standards. TPH were detected in soil samples in concentrations of 53 mg/kg and 530 mg/kg. TPH were not detected in water samples. Metal concentrations in the soil and groundwater samples from this site were generally similar to the basewide hydrogeology wells. The water sample also exceeded Secondary Drinking Water Standards for manganese. Groundwater samples detected di-n-butylphthalate and 1,1,1-trichloroethane at concentrations of 13.0 ug/L and 5.8 ug/L, respectively. These concentrations are below the National Ambient Water Quality Criteria (NAWQC) and EPA MCL Standards. There are no NAWQC or EPA standards for 1,1-dichlorethane, which was detected in the water samples.

The scope of this study does not allow an accurate estimate of the volume of contamination released. Volatile organics and pesticides may be migrating in the groundwater as similar contamination was detected at upgradient Sites IS-1 and IS-3. However, each of these sites has its own source of contamination, which may be the sole source of organic contaminants at each site. Receptors and pathways are present, but contaminant release and migration characteristics have not been shown since only 1 well was sampled and installed at the site.

Solute transport models may be important at Site IS-4. Wells installed to the south and southwest of the site may provide additional hydrogeological data and allow the formation of more accurate solute transport models. The results of this modeling would help to determine the mobility, toxicity and volume (MTV) of the detected contaminants. Further evaluation of the potential risk for downgradient water supplies and surface water could also be assessed.

Further investigation at this site should include the installation of an additional downgradient monitoring well. Soil samples from the proposed well should be analyzed for TPH, pesticides, VOCs, and metals including lead and mercury. Both the proposed and previously installed well should be sampled and analyzed for VOCs, TPH, organochlorine pesticides and PCBs, anions and metals including lead and mercury. A slug test should be conducted in the proposed well.

6.2.6 Recommendations for Site IS-6, Hangar Floor Drains

Site IS-6 is located near Hangar 15, which is used for aircraft maintenance. Floor drains in the building have received minor spillage from these operations; dry wells were incorporated as part of the floor drain system. (Engineering-Science, 1983). Floor drains now discharge to a septic tank and leach pits east of the building. This site is assigned medium priority for further investigation due to contaminant levels exceeding the State of Alaska Primary Water Quality Standards and the potential for offsite migration.

Groundwater and soil samples were sampled and tested for VOCs, TPH, organochlorine pesticides, PCB's, and metals. The primary contaminants in the soils and groundwater are VOCs and TPH. Trichloroethene and tetrachloroethene were detected in the groundwater sample from well IS6-01 at concentrations of 8.1 ug/L and 12 ug/L respectively. The concentrations are above the EPA and MCL standards, respectively. Chloroform (0.32 ug/L) was detected at levels below the NAWQC and EPA RMCL standards. Trichloroethene, tetrachloroethene and chloroform are suspected or known carcinogens. Total TPHs were detected in a groundwater samples in well IS6-01 at a concentration of

0.9 mg/L. Metal concentrations in the soil and groundwater samples from this site were generally similar to the basewide hydrogeology wells. The Secondary Drinking Water Standard for manganese was also exceeded.

Surface soils at Site IS-6 are contaminated with several polycyclic aromatic hydrocarbon compounds (PAH) and chlorinated organic compounds. The soil sample taken at a depth of 5 feet was contaminated with 2-methylphenol at a concentration of 110 mg/kg, pronamide at a concentration of 98 mg/kg, 2,6-dichlorophenol at a concentration of 79 mg/kg, 1,2,4,5-tetrachlorobenzene at a concentration of 88 mg/kg, 2-picoline at a concentration of 115 mg/kg as well as numerous PAHs. Benzo(a)pyrene and 1,2,4,5-tetrachlorobenzene were above soil cleanup levels. The time of travel to receptors is immediate since surface soils are contaminated. The site is located in a developed area of the Base and is easily accessible. Any surface water may become contaminated by the soils.

The scope of this study does not allow an accurate estimate of the volume of contamination released. VOCs may be migrating in the groundwater. Receptors and pathways are present, but contaminant release and migration characteristics have not been determined since only 1 well was sampled and installed at the site.

Solute transport models may be important at Site IS-6. Wells installed to the west (downgradient) and east (upgradient) of the site would provide additional hydrogeological data and allow the formation of more accurate solute transport models. The results of this modeling would help to determine the mobility, toxicity and volume of the detected contaminants. Further evaluation of the potential risk for downgradient water supplies and surface water could also be assessed.

Further investigation at this site should include the installation of 2 additional downgradient monitoring wells and 1 upgradient well. Both the proposed and previously installed wells should be sampled and analyzed for VOCs, PAHs, and TPH and metals including lead and mercury.

6.2.7 Recommendations for Site IS-7, Hangar Floor Drains

Site IS-7 is located near Building 21-900, which is used to maintain most of the vehicles on the base. A series of floor drains are connected to 2 sumps that drain into a seepage pit north of the building. These drains have received spilled fuels and solvents. Ship Creek is located approximately 4000 feet to the south of the site. This site is assigned medium priority for further investigation due to contaminant levels exceeding the State of Alaska Primary Water Quality Regulations and the potential for offsite migration.

Groundwater and soil samples from the site were analyzed for VOCs, TPH, organochlorine pesticies, PCBs and metals. The primary contaminants detected in the soil and groundwater are TPH and VOCs. Groundwater samples were contaminated with trichloroethene at a concentration of 76 ug/L, which is above the State of Alaska and EPA Standards of 5 ug/L. TPH was detected at a concentration of 2.0 mg/L in a groundwater sample from well IS7-01. Since the groundwater sample did not have a petroleum odor or sheen, State of Alaska Primary Drinking Water Standards were not exceeded. Metal concentrations in the soil and groundwater samples from this site were generally similar to the basewide hydrogeology wells. The water sample exceeded the Secondary Drinking Water Standard of 0.05 for manganese.

The scope of this study does not allow an accurate estimate of the volume of contamination released. VOCs may be migrating in the groundwater. Receptors and pathways are present, but contaminant release and migration characteristics have not been determined since only 1 well was sampled and installed at the site.

Solute transport models may be important at Site IS-7. Wells installed to the south and southwest of the site may provide additional hydrogeological data and allow the formation of more accurate solute transport models. The results of this modeling would help to determine the mobility, toxicity and volume of the detected contaminants. Further evaluation of the potential risk for downgradient water supplies and surface water could also be assessed.

Further investigation at this site should include the installation of 4 additional monitoring wells. One well should be located upgradient, 1 well should be near the existing well (and screened in the deeper portion of the aquifer), and 2 wells should be installed downgradient. Both the proposed and previously installed wells should be sampled and analyzed for VOCs and TPH.

6.2.8 Recommendations for Site IS-8, Hangar Floor Drain

Site IS-8 is located near Hangar 5 which is used as the aerial delivery facility and houses many pieces of ground equipment. About 55 gallons of the solvent PD-680 is used over a 3 month period to clean and maintain this equipment; some of this solvent is washed into floor drains which discharge into dry wells. Ship Creek is located approximately 4000 feet south of the site. This site is assigned medium priority for further investigation due to contaminant levels exceeding the State of Alaska Primary Water Quality Regulations and the potential for offsite migration.

Soil and groundwater samples from Site IS-8 were analyzed for VOCs, TPH, organochlorine pesticides, PCBs, and metals. The primary contaminants detected in soil and groundwater samples are TPH and VOCs. Trichloroethene was detected in the groundwater sample at a

concentration of 6.6 ug/L. This concentration is above the State of Alaska and EPA Standard of 5 ug/L. In addition, toluene, 4-methyl-2-pentanone, 1,1-dichloroethane and 1,1,1-trichloroethane were detected in the groundwater sample at concentrations below State of Alaska and EPA Standards. TPH was detected at a concentrations of 2.0 mg/L in a groundwater sample taken from Well 158-01. Since the groundwater sample did not have a petroleum odor or sheen, State of Alaska Primary Drinking Water Standards were not exceeded. The groundwater sample did exceed the Secondary Drinking Water Standard for manganese and iron.

The scope of this study does not allow an accurate estimate of the volume of contamination released. VOCs may be migrating in the groundwater. Receptors and pathways are present, but contaminant release and migration characteristics have not been determined since only 1 well was sampled and installed at the site.

Solute transport models may be important at Site IS-8. Wells installed to the south and southwest of the site may provide additional hydrogeological data and allow the formation of more accurate solute transport models. The results of this modeling would help to determine the mobility, toxicity and volume of the detected contaminants. Further evaluation of the potential risk for downgradient water supplies and surface water could also be assessed.

Further investigation at this site should include the installation of 4 additional monitoring wells. The new wells should be located just as at Site IS-7: 1 upgradient, 1 near the existing well. and 2 downgradient. Both the proposed and previously installed wells should be sampled and analyzed for VOCs and TPH.

6.2.9 Recommendations for Site SP 2/6, Fuel Line Leak and Diesel Line Spill

Site SP-2/6 is the result of a JP-4 leak from an underground pipeline and a diesel fuel spill. The site is located 500 feet northwest of Ship Creek. An unknown quantity of JP-4 fuel seeped out of an escarpment southeast of Building 22-010 during the 1950's and 1960's (Engineering-Science, 1983). An 8,000 gallon diesel fuel spill occurred from an aboveground tank near Building 22-013 in the winter of 1976. The ground was frozen and most of the fuel was recovered. The site has been evaluated through 2 existing monitoring wells and 10 borings, 5 of which were completed as monitoring wells. A soil gas survey delineated the north and east boundaries of the site. The site is assigned medium priority for further investigation due to contaminant levels exceeding the State of Alaska drinking water standards for petroleum hydrocarbons, the soil contaminant levels exceeding the interim ADEC soil cleanup guidelines, and evidence of offsite migration of contaminants.

Soil and groundwater samples collected at Site SP-2/6 were analyzed for TPH, volatile and semi-volatile compounds, purgeable aromatics and extractable priority pollutants. The primary contaminants detected in soil and groundwater samples are TPH and VOCs. Groundwater samples from wells SP2/6-02, SP2/6-03, SP2/6-05, GW-6A and W-16 had petroleum odors and/or a sheen, thereby exceeding State of Alaska Primary Drinking Water Standards. TPH concentrations ranged from 3.5 mg/L to 64 mg/L. TPH contamination of 6.3 mg/L was detected in 1986 in well W-16 but was not detected in 1988. However, TPH concentrations increased in groundwater samples collected from well GW-6A from 6.0 mg/L in 1986, to 64 mg/L in 1988. Well GW-6A is located further downgradient of the site than well W-16. In addition, toluene, ethylbenzene and xylenes were detected in groundwater samples taken from well GW-6A at concentrations of 4.5 ug/L, 30 ug/L and 24.8 ug/L, respectively. These compounds were not found in any other samples.

The most pervasive contaminant is TPH, detected in 4 groundwater samples and 2 soil samples.

The scope of this study does not allow an accurate estimate of the volume of contamination released since quantities spilled or contained and removed were not recorded. Contamination in offsite and downgradient wells indicates the existence of contamination migration. Receptors and pathways are present and a possible threat to human health exists as the site is only 500 feet northwest of Ship Creek.

Solute transport models may be important at this site. Wells installed to the south of the site may provide additional hydrogeologic data and allow the formation of more accurate solute transport models. The results of this modeling would help to determine the mobility, toxicity and volume of the detected contaminants. Further evaluation of the potential risk for downgradient water supplies and surface water could also be assessed.

Further investigation at this site should include a groundwater field screening and product probes to determine the south and southeast limits of the site and aid in the selection of additional monitoring well locations. Four downgradient wells are proposed. The new monitoring wells should be located downgradient and between the toe of the bluff and the railroad tracks. Both the proposed and previously installed monitoring wells should be sampled seasonally and analyzed for TPH, purgeable aromatics, and purgeable halocarbons. The results of these tests should aid in identifying the dilution, diffusion, and dispersion characteristics at the site.

6.2.10 Recommendations for Sites SP-4 and SP-11, Railroad Maintenance Area Oil Spill

It is recommended that sites SP-4 and SP 11 be combined to form 1 site due to their geographical proximity and the similarity of the contaminants found on the site. This new site would be assigned

medium priority for further investigation due to contaminant levels exceeding the State of Alaska Primary Water Quality Standards and evidence of offsite migrations of contaminants.

The following are descriptions of the sites:

Site SP-4 is the location of an oil spill in the late 1960's (Engineering-Science, 1983). Oil globules were seen seeping out of the bank near the railroad maintenance facility and collecting in the marshy area. Site SP-4 is located approximately 600 feet north of Ship Creek and is near the cooling pond on the south part of the base. The site has been examined using a soil gas survey and 3 monitoring wells.

Site SP-11 is the location where an undetermined amount of JP-4 fuel was spilled in 1978 as a result of a crack in an underground pipe (Engineering-Science, 1983). The pipe was repaired but fuel continued to seep from the bank of a nearby stream. During Phase II, Stage 1 and 2 investigations, 2 monitoring wells were installed, GW-4A and W-14. These monitoring wells were resampled in 1988.

Groundwater and soil samples at Sites SP-4 and SP-11 were analyzed for TPH, VOCs, organochlorine pesticides, PCB's and extractable priority pollutants. TPH were detected in groundwater samples at concentrations ranging from 1.0 mg/L to 3.3 mg.L. TPH were detected in well GW-4A in 1986 at a concentration of 24.0 mg/L and in 1988 at a lower concentration of 3.0 mg/L. Benzene was detected in 3 out 5 monitoring wells at concentrations ranging from 3.0 to 27.0 ug/L. The MCL for benezene is 5.0 ug/L. The groundwater cleanup level for petroleum hydrocarbons is no odor or sheen. Several compounds, including dibromochloromethane, tetrachloroethene, trichloroethene and trichlorofluoromethane, that were detected in 1986 samples were not detected in 1988 samples.

The scope of this study does not allow an accurate estimate of the volume of contamination released since the size of the spills and clean up efforts were never recorded. Contamination in offsite and downgradient wells indicates the probability of offsite migration. Receptors and pathways are present, and the presence of carcinogenic compounds above State of Alaska Standards indicates that further investigation will be required at this site.

Solute transport models may be important at Site SP-4/11. Wells installed to the south and southwest of the site may provide additional hydrogeological data and allow the formation of more accurate solute transport models. The results of this modeling would help to determine the mobility, toxicity and volume of the detected contaminants. Further evaluation of the potential risk for downgradient water supplies and surface water could also be assessed.

This site should be combined with Site SP-11 and analyzed as 1 site. Further investigation at the combined site should include installation of 5 new soil borings; 2 of the borings should be developed as groundwater monitoring wells. Both the proposed and previously installed wells should be sampled and analyzed for TPH, purgeable aromatics, and purgeable halocarbons. The drinking water well (Base Well 52), located approximately 3000 feet downgradient from the site, should be sampled and analyzed to ensure that no contamination has migrated to the confined aquifer. Two surface samples should be collected from the ponds located near wells SP4/11-01 and W-14.

6.2.11 Recommendations for Site NS-1, Cherry Hill Ditch

Site NS-1 (Cherry Hill Ditch) is a drainage channel that flows toward the west from the east-west runway to Knik Arm. The headwaters of the ditch consist of a 30-inch pipe that discharges water at an estimated rate of 200 gallons per minute. The water table is generally at a

depth of 20 feet and occasionally is found at or near the surface. The Cherry Hill Ditch is the primary drainage in the area and appears to receive considerable flow from the shallow groundwater system (Engineering-Science, 1983). Additional sources of flow are presumed to be drains from under the runway and building drains and parking lot runoff. The runoff is expected to contain JP-4, diesel and MOGAS fuel, along with deicing fluids and solvents. This site is assigned medium priority for further investigation due to detection of TPH and suspected carcinogens in water and stream sediment samples.

Four water samples and 4 sediment samples were collected from Cherry Hill Ditch. PAHs and TPH were detected in stream sediment samples. Water samples from NS1-02, NS1-03, NS2-04 exhibited a petroleum odor, sheen, and or foam, thereby exceeding State of Alaska Water Quality Standards. Chloroform and 1,1,1-trichloroethane were detected in surface water samples from the locations identified NS1-03 and NS1-04, but at levels below the EPA MCLs. Water samples exceeded Secondary Drinking Water Standards for manganese and iron.

TPH was detected in a sediment sample from NS1-03 at a concentration of 440 mg/kg. The following PAHs were also detected in the sediment sample: Benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, chrysene, fluoranthene, phenanthrene and pyrene. The time of travel to receptors is immediate since surface water is contaminated. The site is located in a developed areas of the base and is easily assessable. Time of travel is negligible.

The scope of this study does not allow an accurate estimate of the volume of contamination released. Receptors and pathways are present, and contaminant release and migration characteristics have been identified.

Solute transport models may be important at Site NS-1. The results of this modeling would help to determine the mobility, toxicity and volume of the detected contaminants. Further evaluation of the potential risk for downgradient water supplies and surface water could also be assessed.

Further investigation at this site should include additional sampling of Cherry Hill Ditch water and sediments at the 4 locations sampled during this stage. In addition, 2 new sampling locations should be added near NS1-03: 1 in the storm drain which discharges to the ditch and 1 just upgradient of where the storm drain discharges. Also, the foam which collectes on the ditch should be sampled. These foam, water, and sediment samples should be sampled and analyzed for VOCs, TPH, and metals (ICP screen). Foam and water samples should also be analyzed for surfactants. The sediment samples should be also analyzed for semi-volatile organic compounds, lead, and mercury.

6.2.12 Recommendations for Site D-15, POL Sludge Disposal Site No. 1

Site D-15 is a 1 acre area that was used from 1964 to 1968 to dispose of Petroleum, Oils and Lubricants (POL) tank sludge and to weather fuel filters and pads. The site was closed with local soil cover (Engineering-Science, 1983). The site is assigned low priority for further investigation due to the detection of TPH in the soil.

The site was evaluated by using a terrain conductivity geophysical survey, installating 2 shallow boreholes, and analyzing of 4 soil samples. Interpretation of the geophysical survey results indicate the presence of metallic materials in the disturbed area in the center of the site and high conductivities in the southwest corner of the site. Site geophysics provided data to place the test borings in positions to sample soils most likely contaminated by POL sludge. Two 5 foot test borings were dug; the following observations were made during excavation of the borings: At boring D15-01, an HNu reading of

0.2 ppm was recorded from a soil sample taken at a depth of 1 foot. At boring D15-02, an HNu reading of 0.3 ppm was recorded from the soil sample taken at a depth of 1 foot, an HNu reading of 10 ppm with a petroleum odor was recorded on a soil sample taken at a depth of 3 feet, and an HNu reading of 50 ppm with a strong petroleum odor was detected on a soil sample taken at a depth of 5 feet.

TPH was detected at concentrations of 260 mg/kg and 2590 mg/kg in soil samples taken from boring D15-02 at depths of 1-1.5 feet and 4.5-5.0 feet, respectively. Lead concentrations ranged from 6.5 mg/kg to 20 mg/kg, similar to lead concentrations in the basewide hydrogeology (background) wells. The concentrations of TPH detected exceed the levels suggested by the interim ADEC guidelines.

Drilling and sampling operations at Site D-15 did not reach the groundwater. Therefore it is not possible to determine if groundwater is contaminated in the vicinity of Site D-15. The scope of this study does not allow an accurate estimate of the volume of the contamination released. Receptors and pathways of exposure exist since surface soil was contaminated and the site is located in an easily accessible area.

The applicability of solute transport models at Site D-15 cannot be determined by this study as the hydrogeology of the site is not known. Further investigations are required to determine if contamination has reached the groundwater.

Further work at this site should include a soil gas survey to determine the limits of the concentration and aid in locating 3 monitoring wells. The wells will confirm the direction of groundwater flow and estimate the flow rate and hydraulic conductivity in the area. Soil and groundwater samples should be tested for TPH and VOCs. Soil samples should also be analyzed for constituents regulated by the Anchorage Regional Landfill for disposal. Also, if petroleum products

are discovered floating on the groundwater, a measurement of thickness of the layer should be taken.

6.2.13 Recommendations for Site SP-13, Diesel Fuel Line Leak

Site SP-13 is the location of a 1968 diesel fuel spill. Approximately 800 gallons of fuel seeped into the ground as a result of a pipeline leak and no fuel was recovered (Engineering-Science, 1983). The site is assigned low priority for further investigation due to the detection of TPH and PAHs in the soil. TPH in the soil samples were detected above cleanup levels. PAHs were also detected. However, since that time, an asphalt parking lot has been installed at the site, effectively capping the site and removing any threat to human health or the environment from ingestion or handling of the soil. A potential threat of groundwater contamination still exists at this site.

Soil samples from 2 shallow boreholes were analyzed for TPH and volatile and semi-volatile organic compounds. TPH concentrations in surface soil samples were 38 mg/kg and 210 mg/kg for boring SP13-01 and SP13-02, respectively. In addition the following PAHs were detected in soil samples from boring D13-02: benzo(b)fluoranthene, chrysene, fluoranthene, phenanthrene, and pyrene. The concentrations of these PAHs are less than 1.3 mg/kg.

Evaluation of the potential risk for downgradient water supplies should be assessed at this site. Further investigation at this site should include the installation of 1 downgradient monitoring well. A soil gas survey should be performed to better characterize the area of contamination and results from this survey should be used to place the boring/monitoring well. Groundwater from the well should be sampled and tested for TPH, purgeable aromatics, and polynuclear aromatic hydrocarbons. A minimum of 2 soil samples should be collected from

the boring and analyzed for TPH, VOCs, and polynuclear aromatic hydrocarbons. In addition, measurement of floating fuel product thickness should be taken if fuel product is seen floating at the surface of the groundwater in the well.

6.3 CATEGORY 3

Category 3 contains 7 sites which were evaluated in the FS. The sites are D-16, IS-1, SP-5/5A, SP-7/10, and SP-15. This section presents a summary of the detailed evaluation of the remedial alternatives in terms of costs, public health impacts, environmental impacts, technical feasibility, institutional requirements and community concerns. A summary of these items is presented in Table 6-2.
The source of contamination at the FS sites designated for remedial action has been associated with the release of petroleum products into the environment. The released petroleum products common to each site are aviation gasoline and/or jet fuels. The hazardous contaminants of concern from these products are the volatile aromatic hydrocarbons benzene, ethylbenzene, toluene, and xylene (BETX). The BETX compounds have varying degrees of toxicity. Benzene is of most concern because it is known to cause cancer in humans. These compounds share the common characteristic of being both volatile to the atmosphere and soluble in water. Total petroleum hydrocarbon (TPH) from released fuel products also represents a concern in soil and groundwater at each of the sites. However, TPH is less volatile, less soluble and has less risk associated with exposure.

TPH was detected at Site D-16 at concentrations ranging from nondetectable to 8,160 mg/kg. The maximum detected concentrations for BETX and TPH at Sites IS-1, SP-5/5A, SP-7/10, and SP-15 are presented in Table 6-3. Target cleanup levels for these constituents in groundwater are also presented in Table 6-3.

TABLE 6-2. SUMMARY OF DETAILED EVALUATION OF REMEDIAL ALTERNATIVES

Alternative	Average Cost Per Site ($1000) Capital	Present Worth	Public Health Impacts	Environmental Impacts	Technical Feasibility	Institutional Requirements	Community Concerns
1 No Action	-	-	o Contaminant releases uncontrolled. o Potential ingestion of contaminants toward active drinking water wells. o Contaminants remain in groundwater for a long time period.	o Contaminants remain in groundwater. o Continued migration of plume in aquifer. o Potential for discharge into surface waters. o Continued release of fuel product at SP-5/5A.	N/A	Does not meet ARARs.	Potential exposure to contaminated well water. Not acceptable to public.
2 Groundwater Monitoring, Groundwater Use Restrictions, Alternate Water Supply	27.5	285	o Prevents ingestion of of contaminated well water. o Contaminant releases uncontrolled. o Contaminants remain in groundwater for long time period.	Same as Alternative 1.	o Effectively and reliably provides safe drinking water supply. o Does not reduce toxicity or concentration of contaminants.	o Does not meet ARARs. o Groundwater use restrictions require enforcement. o Approval of remedial action may be difficult to obtain.	o Surface waters may become contaminated. o Continued uncontrolled release at SP-5/5A. o Groundwater remains contaminated.
3 Collection, Onsite Air Stripping Surface Discharge	988	1,160	o Reduces contaminant concentrations to drinking water standards in groundwater and in surface discharge. o Prevents ingestion of contaminated water supplies.	o Effectively contains and controls releases of fuel product a SP-5/5A. o Drinking water supplies are protected. o Discharge waters meet drinking water standards. o Minimal impacts on ambient air quality.	o Effective well establish technologies. o Well demonstrated performance under similar site conditions and contaminant characteristics.	o Meets ARARs. o NPDES permit required to discharge treated effluent.	Acceptable Alternative.
6 Collection, Onsite UV/Oxidation, Surface Discharge	1,470	1,950	Same as Alternative 3.	Same as Alternative 3.	o Relatively new technology for groundwater remediation. o Requires pilot plant and treatability studies. o Destroys contaminants. o Requires some operator assistance.	Same as Alternative 3.	Acceptable Alternative.
7 Containment by Surface Capping (Site D-16)	841	909	o Minimizes leachate production. o Reduces contaminant migration into ground water and surface water. o Minimizes potential risk of exposure to contaminated surface soils and runoff.	o Reduces concentration and duration of contaminants discharged to surface and groundwater. o Contaminated soils are left in place.	o Effectively and reliably controls migration of contaminants into groundwater and surface runoff. o Does not reduce toxicity or concentration of contaminants.	Does not attain ARARs but reduces threats to public health and environment.	May meet with some resistance because environment remains contaminated.
9 Excavation, Offsite Local Landfill	1,930	1,950	o Minimizes contaminant migration into groundwater and surface runoff. o Minimizes potential risk of exposure to contaminated surface soils and runoff.	o Removes contaminated soils from the site. o Minimizes concentration and duration of contaminants discharged to surface and groundwater.	o Effectively removes source of contamination at the site. o Quickly implemented. o Does not reduce toxicity or concentration of contaminants.	o Meets ARARs. o Soils must meet landfill requirements for contaminant concentrations.	Acceptable Alternative.

TABLE 6-2 (Continued). SUMMARY OF DETAILED EVALUATION OF REMEDIAL ALTERNATIVES

Alternative	Average Cost Per Site ($1000) Capital	Average Cost Per Site ($1000) Present Worth	Public Health Impacts	Environmental Impacts	Technical Feasibility	Institutional Requirements	Community Concerns
10 Excavation, Offsite RCRA Landfill	8,770	8,790	Same as Alternative 9.	Same as Alternative 9.	Same as Alternative 9.	o Meets ARARs. o Required if soils fail to meet sanitary landfill requirements.	Acceptable Alternative.

TABLE 6-3. TARGET CLEANUP LEVELS FOR GROUNDWATER

Contaminant	Maximum Detected Contamination (ug/L)				Target Cleanup Levels (ug/L) (1)
	IS-1	SP-5/5A	SP-7/10	SP-15	
TPH	Pure Product	Pure Product	Pure Product	3,000	(2)
Benzene	35	21,000	3,200	170	5
Toluene	460	26,000	7,100	300	2,000
Ethylbenzene	250	2,700	1,300	100	700
Xylene	1,050	10,900	5,100	400	440

(1) Based on ADEC Proposed Soil and Groundwater Cleanup Standards Discussion Draft: December 2, 1988.

(2) Use Water Quality Criteria.

The potential exposure pathways at the sites include consumption of, and contact with, contaminated groundwater and/or soil. In addition, the potential may exist for offsite transport of contaminants through migration of groundwater to receptor wells, surface waters and by leaching of soil contaminants into underlying groundwater. Most of the potentially affected receptor wells are not screened in the shallow groundwater system and should not be impacted by the contaminants unless well construction techniques allowed cross-contamination between the aquifers, or if other hydraulic connections exist between the shallow and deep groundwater systems. Base well 1, which is located at Building 23-900, is an exception since it is screened at a depth of only 16 feet into the shallow aquifer.

6.3.1 Recommendations for Site D-16.

Since TPH concentrations in soil samples taken at Site D-16 are above interim ADEC cleanup levels and because SARA stresses the use of technologies which significantly reduce the toxicity, mobility, or volume of wastes, it is recommended the contaminated soils be removed from Site D-16 and landfilled.

Contaminated soil at Site D-16 should be excavated and disposed of at the Anchorage Regional Landfill facility which accepts soils containing TPH concentrations of less than 1000 ppm. Standard landfill operating equipment, such as, bulldozers, backhoes, and dump trucks should be used to remove contaminated soil and transport it to the local landfill. The 3 concrete slabs on the site should be decontaminated, broken apart and transported to the landfill. All remaining fuel filters and pads should also be transported and disposed of with the soils. The Regional Landfill is contained with a high density polyethylene liner and is equipped with a leachate collection system and a groundwater monitoring system.

HNu (or other organic vapor analyzing devices) readings will be used as a guide for determining the limits of excavation dimensions. When sufficiently low HNu readings are obtained, soil samples will be collected and analyzed. This procedure will continue until TPH levels are less than 100 ppm throughout the site. Local borrow material will then be imported to backfill the excavation and complete the site remediation.

The Anchorage Regional Landfill cannot accept hazardous wastes. Soils at Site D-16 were analyzed only for TPH, lead, and total solids during the RI. Since past disposal practices at the site have involved petroleum products, a complete soil analysis of total petroleum hydrocarbons and volatile organic compounds will be required before disposal can be permitted in the landfill. Specific landfill requirements are listed in Appendix Q. If average TPH concentrations are above 1000 ppm or if VOCs are sufficiently high to designate the soil a hazardous waste, a RCRA-permitted landfill, described in Alternative 10, will be required for disposal.

A soil gas survey should be conducted to discern the south, west, and north limits of contamination. A total of 5 borings should be installed. One of the borings should be drilled to a depth of 10 feet to examine the extent of soil contamination. Four of the borings should be completed as monitoring wells. Two of the wells should be placed downgradient (north and northeast) of the site; 1 upgradient of the site; and 1 within the site boundaries. The fifth soil boring should be north of the original borings. The estimated total depth of the wells at Site D-16 will be 50 to 70 feet based on regional groundwater patterns. The purpose of groundwater monitoring is to first establish whether or not groundwater has been contaminated at the site and second to verify that contaminants are not migrating offsite. The soils and groundwater should be analyzed for TPH and VOCs. PCBs, arsenic, and chromium should be analyzed in the soil as these parameters are regulated by the Anchorage Regional Landfill.

6.3.2 Recommendations for Sites IS-1, SP-5/5A, SP-7/10, and SP-15

Of all of the alternatives considered for groundwater remediation at Site IS-1, SP-5/5A, SP-7/10, SP-15, the pump and treat technologies of Alternatives 3 and 6 attain the highest overall level of protection of human health and the environment. Alternative 3 and 6 were described in detail in Section 5.4 of the Alternative Remedial Measures Section of the RI/FS. The 2 alternatives also satisfy each of the remedial objectives presented in Section 5.2.1 for protection of human health and the environment. Specifically, groundwater extraction wells in combination with the product discovery systems are capable of containing and collecting contaminated groundwater and effectively minimizing migration to other receptors. The interceptor trench and collection system proposed for Site SP-5/5A provides an effective remedy to control and contain fuel product releases into the environment from the active seep area. The potential for contact with or ingestion of contaminated water supplies is minimized by the installation of a reliable groundwater monitoring system at each site and by periodic monitoring of active drinking water wells. The treatment system of both alternatives is capable of reducing contaminant levels in both groundwater and treated discharge to below established drinking water standards.

Both alternatives 3 and 6 have identical monitoring, extraction, collection, pretreatment and discharge systems. The 2 differ only in treatment technology. In comparing air stripping with UV/Oxidation, both technologies are capable of attaining the same high degree of removal efficiency for BETX contaminants. However, air stripping has undergone considerably more field testing and practical application under conditions similar to those present at Elmendorf AFB. UV/Oxidation, on the other hand, is considered by many to be an

emerging and innovative technology for groundwater remediation. The technology has the advantage of providing destruction of the contaminants by oxidation. However, a proven and reliable track record has yet to be established. Moreover, the evaluation of costs in Section 5.5.5 show the air stripping alternative to be the more cost effective of the 2 alternatives.

Therefore, monitoring, collection, pretreatment, onsite air stripping, and surface discharge as described under Alternative 3 is recommended for groundwater remediations at sites IS-1, SP-5/5A, SP-7/10, and SP-15. The detailed description and cost evaluation for Alternative 3 were based on an analysis of probable site conditions as presented in Section 5.2.3. As reported in this section, the field investigation program did not completely characterize individual sites and further investigation is needed. The information obtained from the 1988 field investigation program was used to develop a conceptual model defining the set of conditions likely to exist at each site and the reasonable deviations from probable site conditions in terms of nature of contamination, extent of contamination, source of contamination and hydrogeologic conditions. As more needed information is developed, the description and cost of the alternative will change. However, most variations will be associated with design features such as placement and sizing of groundwater extraction wells, location and sizing of product recovery systems, and sizing of air stripping components. The changes are not expected to affect the outcome of final alternative selection for remediation of groundwater. Alternative 3 with the same components and methodology will remain the recommended remedial action for each of the sites.

As discussed during the detailed description of Alternative 3, product recovery should proceed as the first step to groundwater remediation in order to remove the concentrated source of floating fuel product at Sites IS-1, SP-5/5A, and SP-7/10. This step will reduce further

dissolution of contaminants into groundwater and thereby reduce the total time and cost of cleanup. Excavation of the interceptor trench and installation of a product recovery system should be implemented as a first step at Site SP-5/5A in order to contain and control fuel product at the seep area. At the same time, inspection of underground storage tanks and piping should be conducted to determine if leaking tanks and/or piping are actively contributing to site contamination. Installation of the treatment facility must precede product recovery at each site in order to provide a means for treatment of the separated water.

Groundwater extraction and treatment should follow product recovery and continue with monitoring until target cleanup levels are attained. Monitoring of active base wells used for drinking water should also begin as soon as possible in order to reduce the potential risks of contact with or ingestion of contaminated water supplies.

There is currently no evidence to suggest that source contamination exists in the vadose zone at each of the sites that would contribute to substantial long term migration of contaminants into the groundwater. Secondly, the extent of soil testing to date is not sufficient to conclude, without question, that there are no remaining sources of released fuel product in the vadose zone. Further testing should be conducted to determine if any source locations exist, and if so, the spatial extent of contamination and the potential long term effect it may have on groundwater cleanup should also be determined.

In the event that a substantial source of contamination is found in the vadose zone at a given site, technologies such as surface capping and soil vapor extraction should be reconsidered. Vapor extraction has shown favorable removal of BETX compounds from soils contaminated with fuel product. While vapor extraction is a viable approach to assisting groundwater cleanup by removing contaminants from the unsaturated zone, it is not by itself as effective for groundwater remediation as the pump and treat methods evaluated.

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CORPS OF ENGINEERS

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NOTES

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THE POINT OF ORIGIN FOR THE ELMENDORF COORDINATE SYSTEM AT 110,000 NORT
AND 110,000 EAST THE THEATA ANGLE AT THIS STATION IS +0° 10' 03" AND TH
SCALE FACTOR IS 0 9999013

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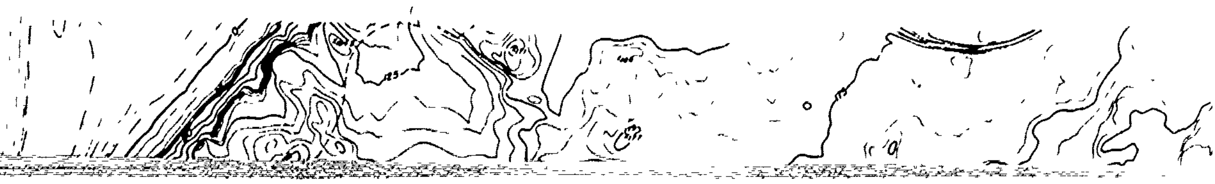

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NOTES

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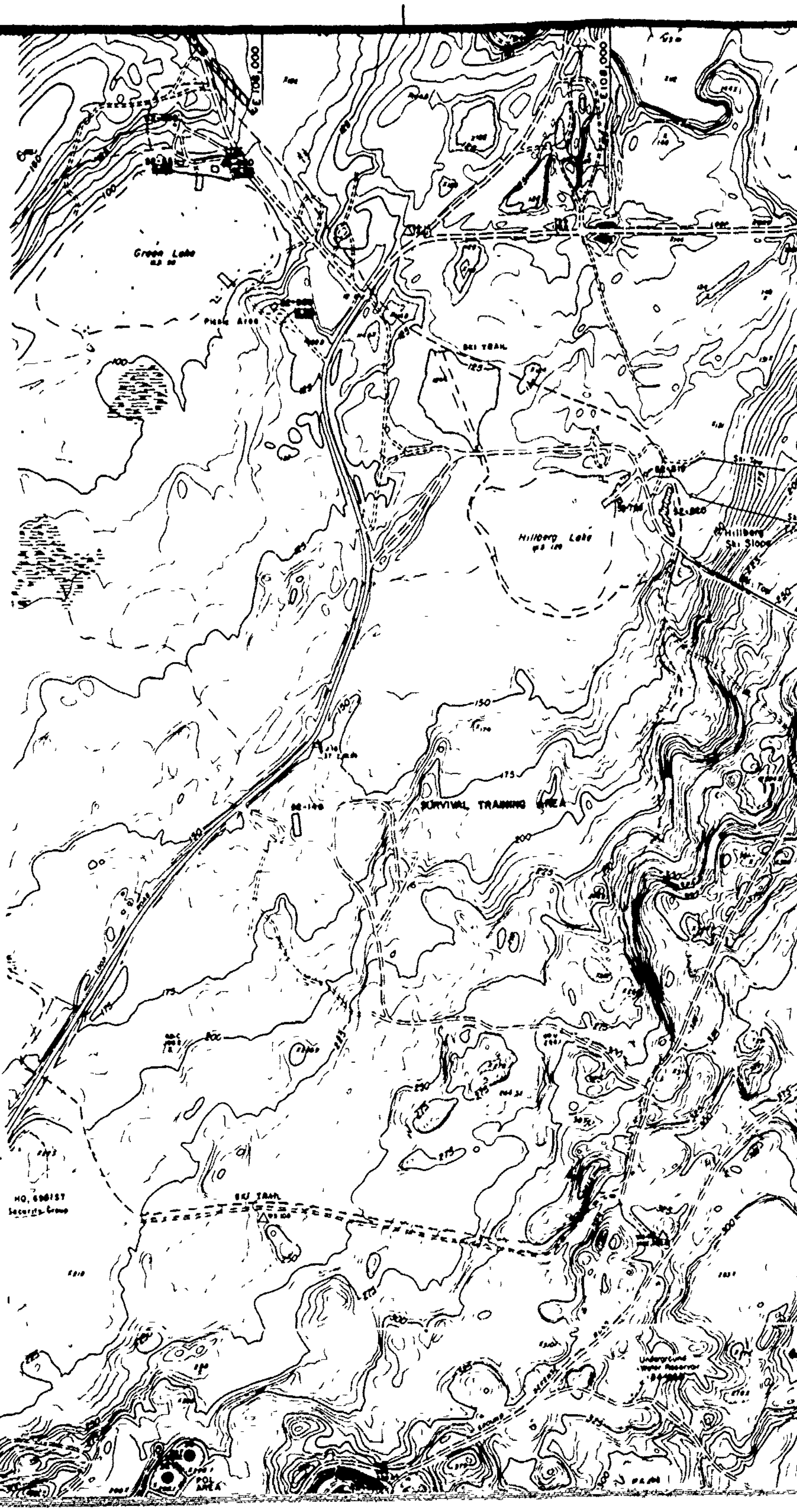

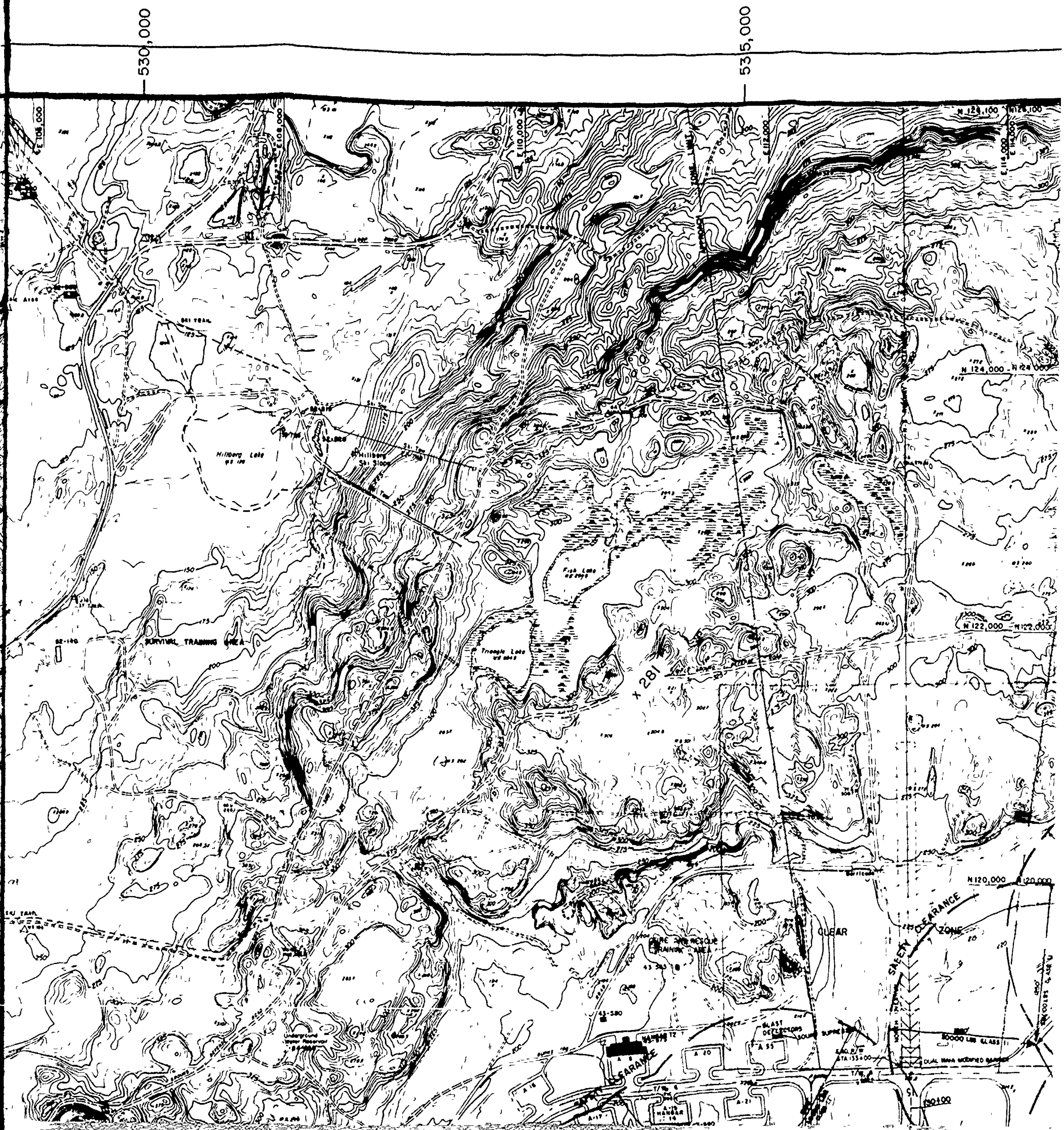
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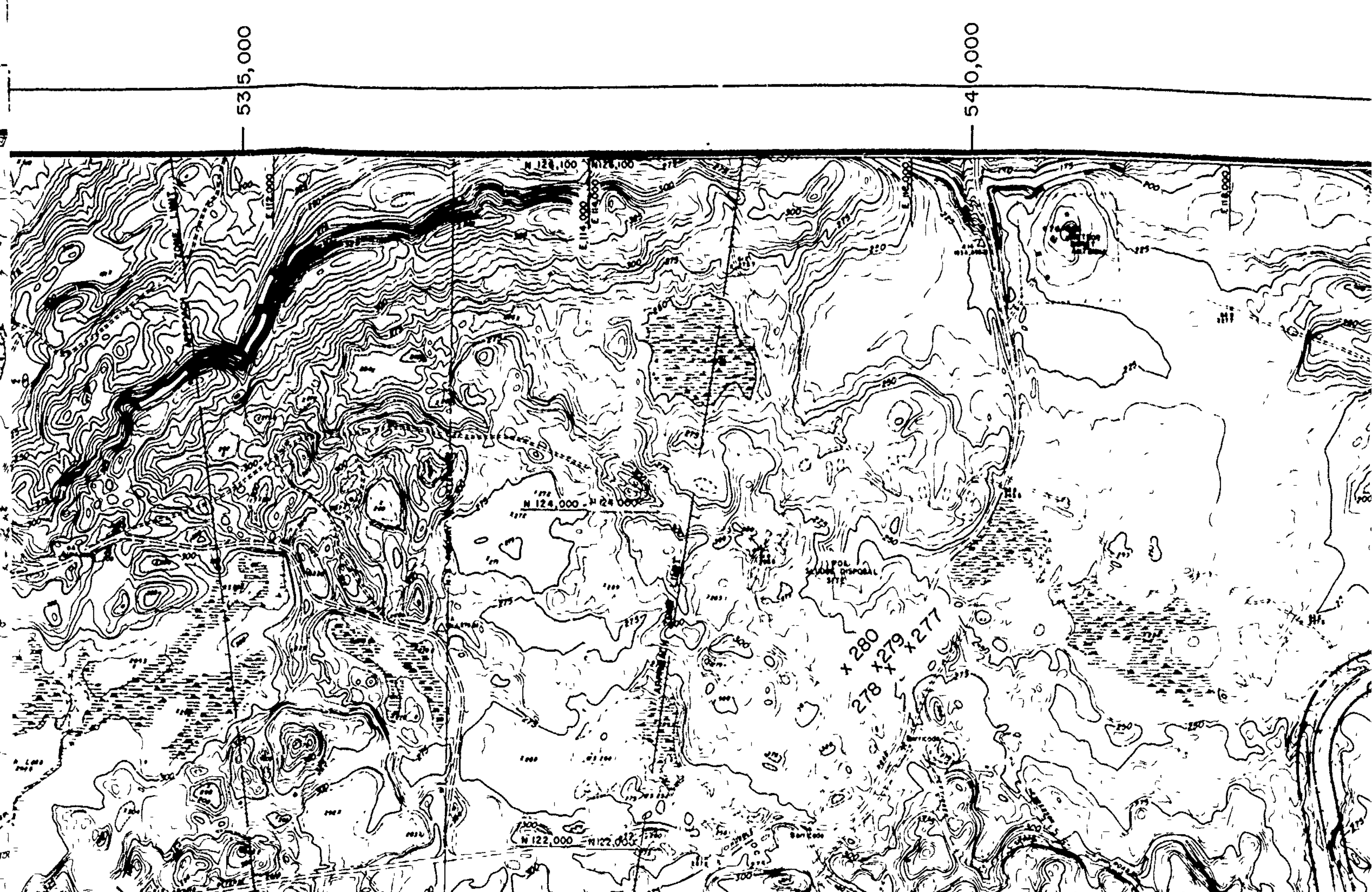
BLAST DEFLECTORS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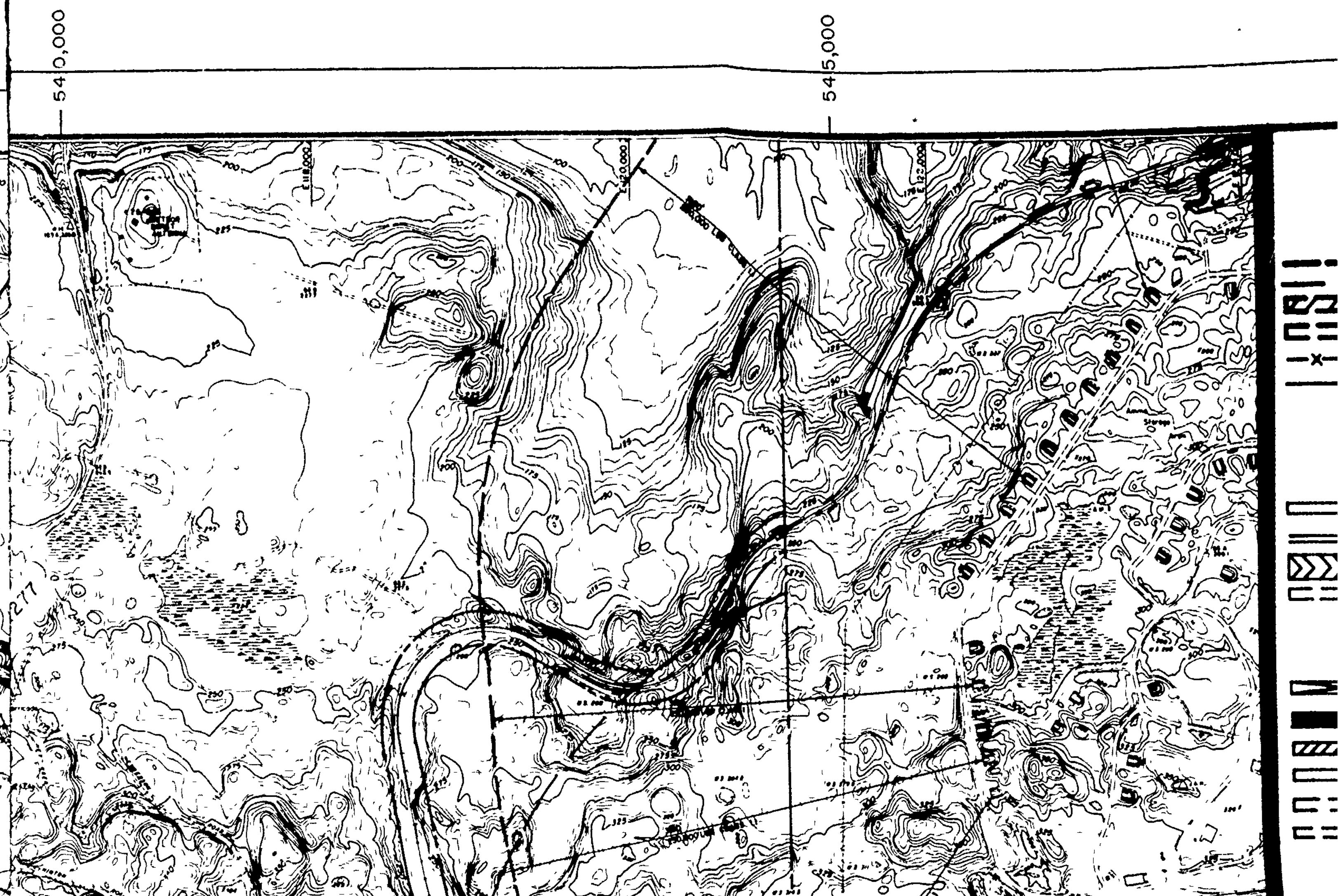
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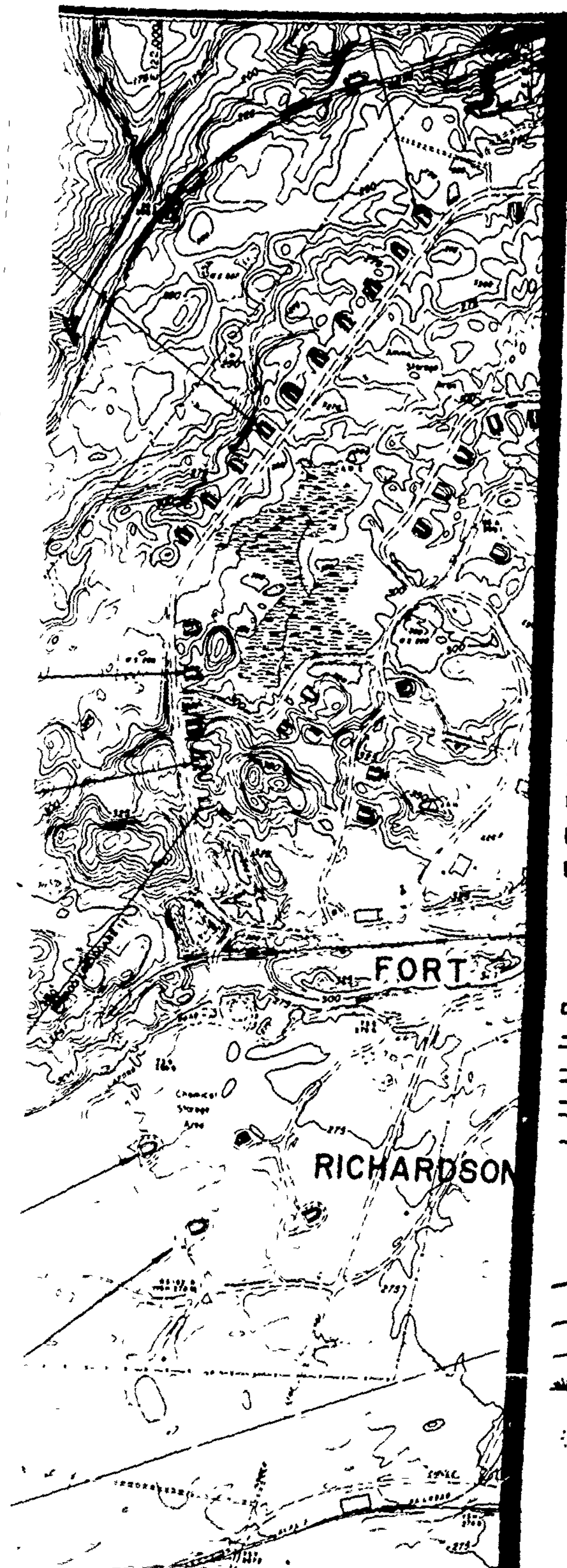
LIMIT

U. S. ARMY



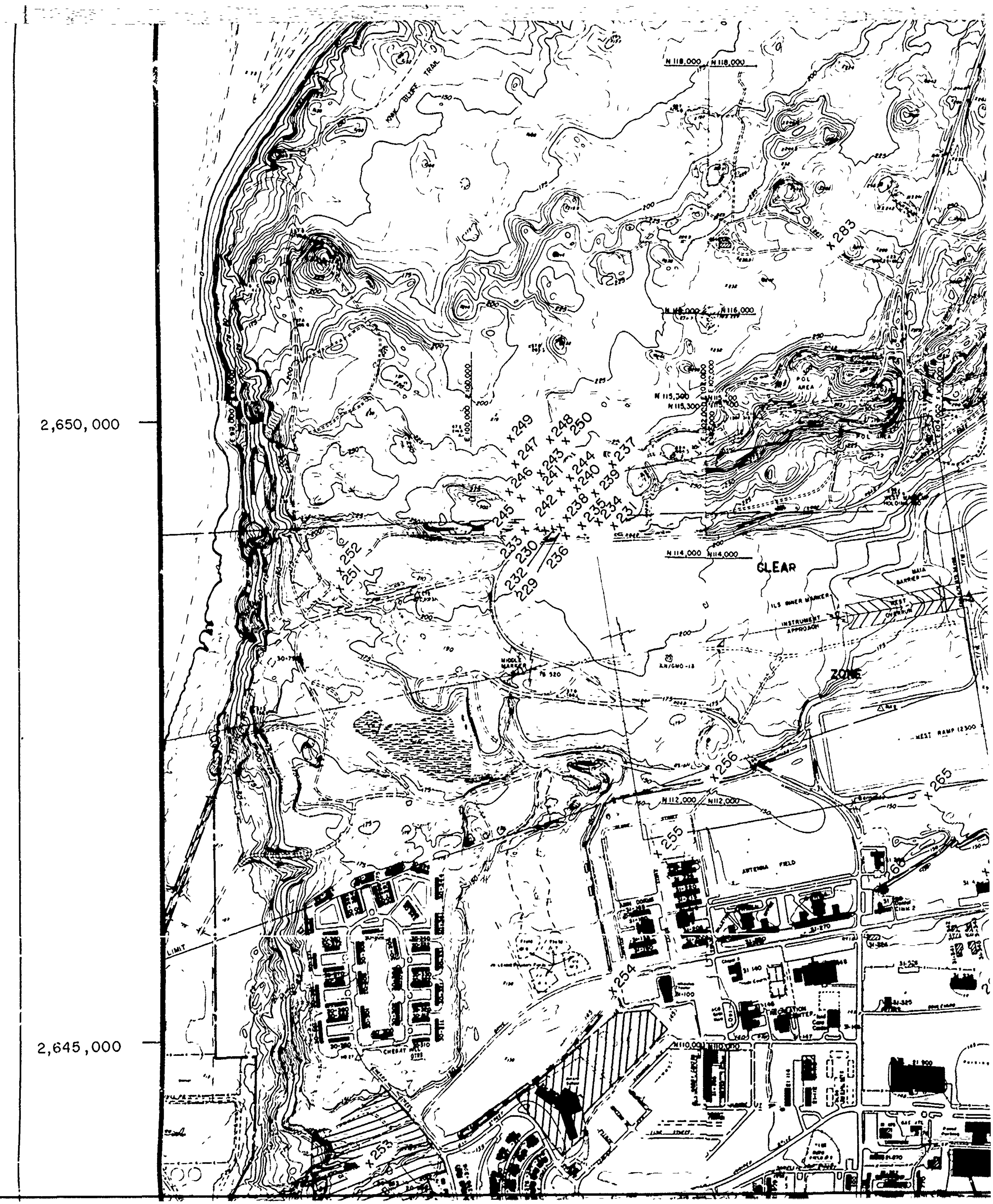
RESERVATION BOUNDARY
EASEMENT(E), LEASE(L), PERMIT(P)
OUTGRAN
AREA LIMIT
FENCE
APPROACH-DEPARTURE ZONE & RUNWAY CLEARANCES

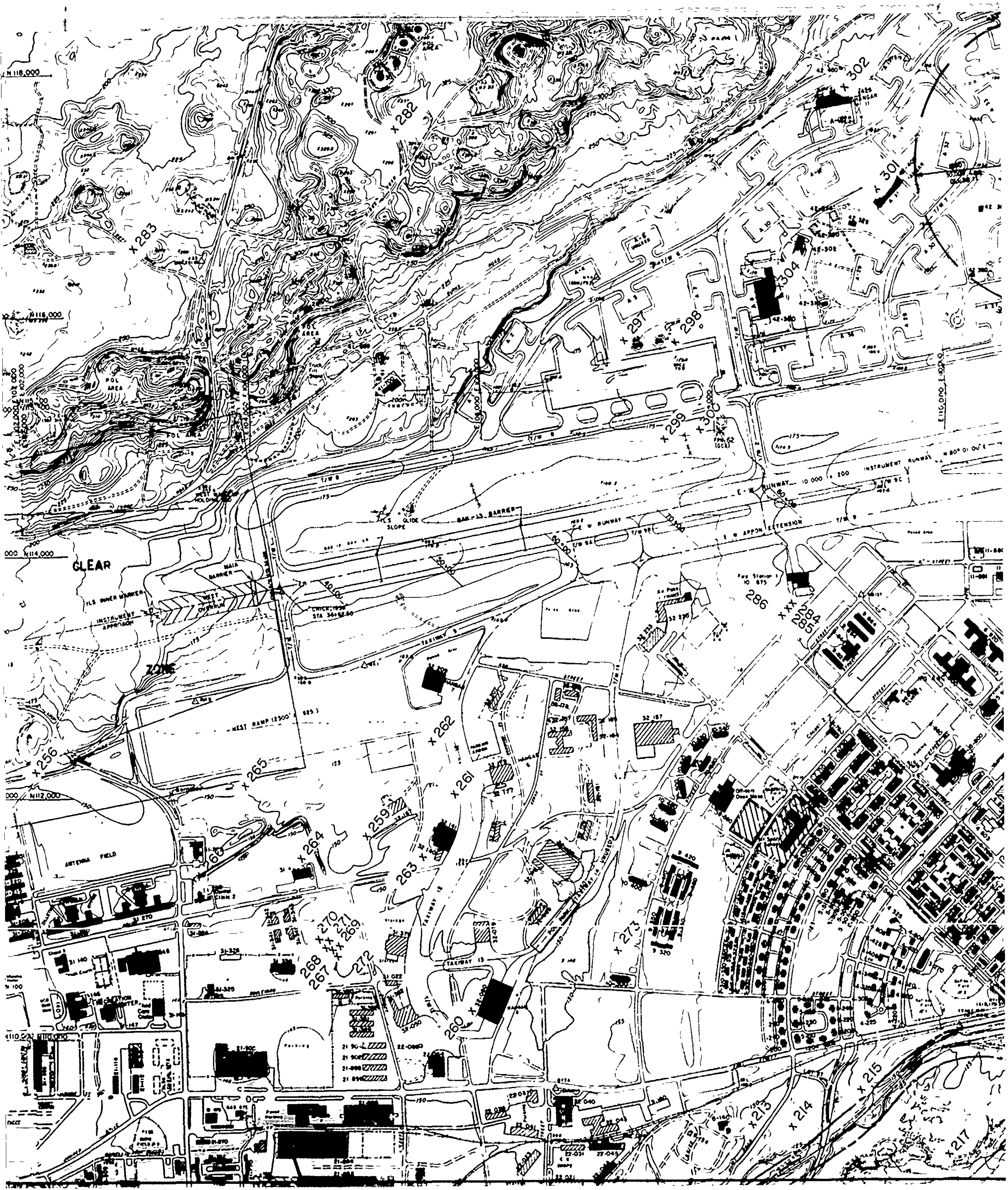
PAVEMENT UTILIZED
STABILIZED SHOULDER
OVERRUN
EXISTING TO BE ABANDONED

EXISTING TO BE ABANDONED(OR REMOVED)
PERMANENT
SEMI-PERMANENT
TEMPORARY
UNDERGROUND
FOUNDATION OR SLAB
EXISTING TO BE MODERNIZED

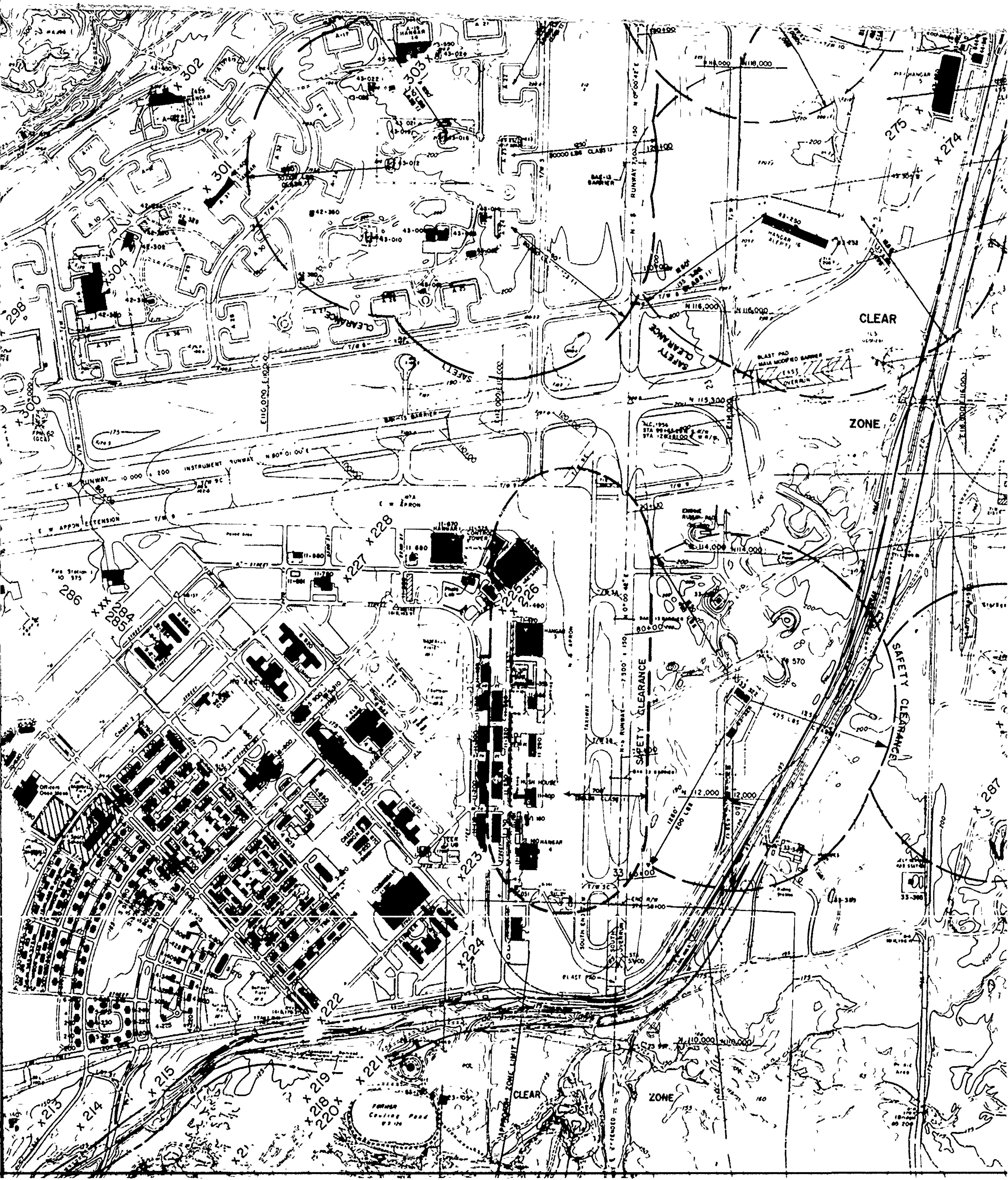
PARKING AREA (PAVED)
PAVED ROAD
UNPAVED, MAINTAINED
UNIMPRROVED
RAILROAD
RAILROAD TO BE ABANDONED

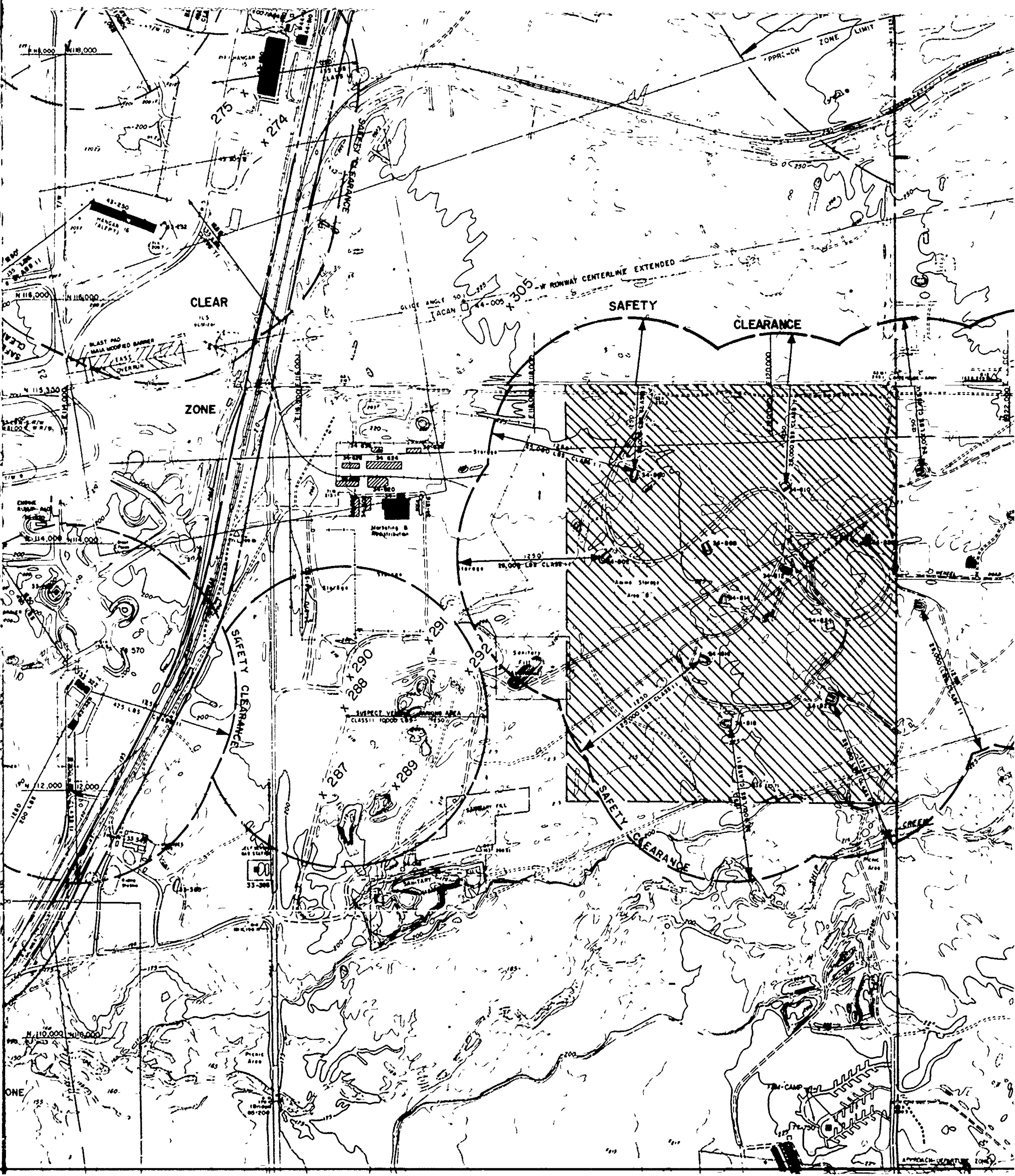
SHORELINE
STREAM
INTERMITTENT STREAM OR DITCH
MARSH OR SWAMP
LAKE OR POND

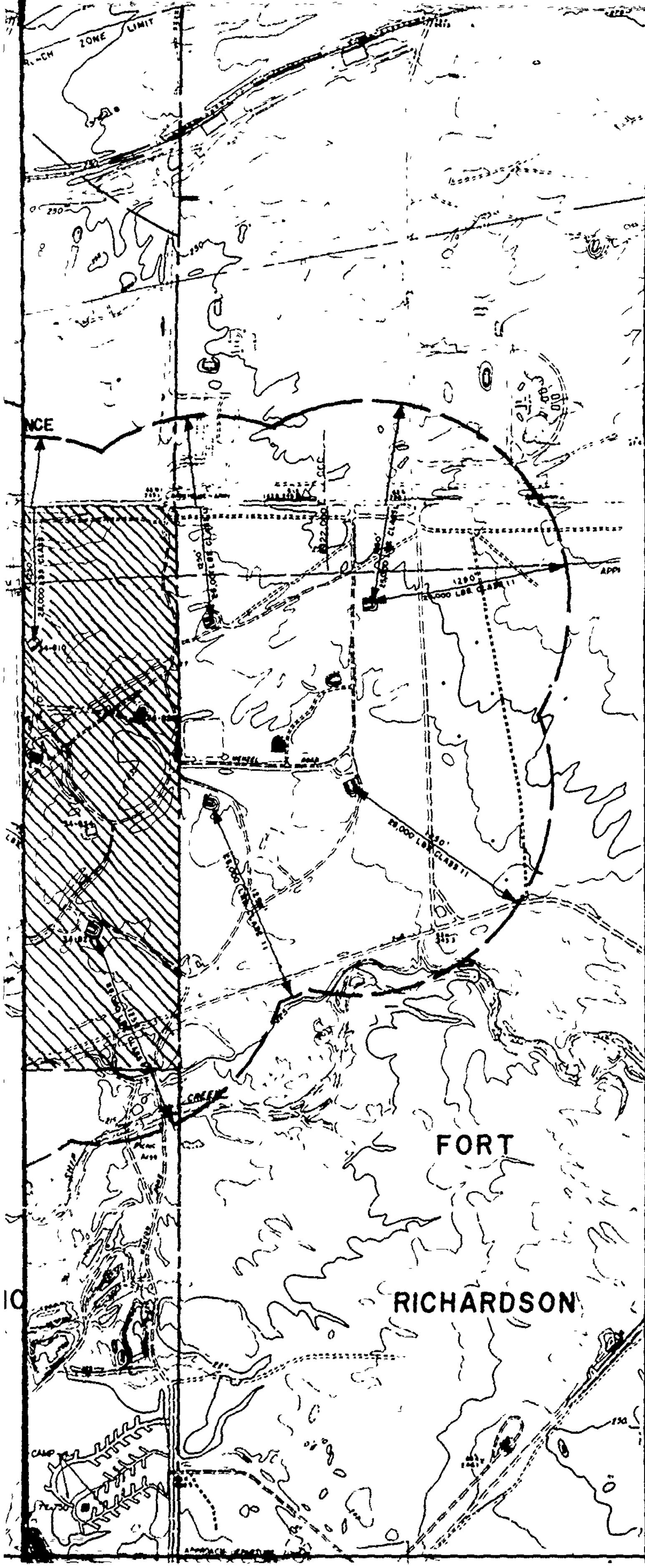

2,650,000
2,645,000
KNIK BLUFF TRAIL
N 118,000
N 116,000
N 115,300
N 114,000
N 112,000
N 110,000
POL AREA
CLEAR
ZONE
ILS INNER MARKER
INSTRUMENT APPROACH
WEST OVERRUN
MIDDLE MARKER
WEST RAMP
ANTENNA FIELD
LIMIT
x 283
x 249
x 247
x 248
x 250
x 246
x 243
x 241
x 244
x 237
x 245
x 242
x 240
x 239
x 238
x 235
x 234
x 231
x 233
x 230
x 232
x 229
x 236
x 252
x 251
x 256
x 265
x 255
x 254
x 253



N 118,000
N 116,000
N 114,000
N 112,000
CLEAR
ZONE
POL AREA
ANTENNA FIELD
WEST RAMP
E-W RUNWAY
INSTRUMENT RUNWAY
TAXIWAY 13
x 282
x 283
x 256
x 265
x 262
x 261
x 259
x 264
x 263
x 260
x 273
x 297
x 298
x 299
x 300
x 301
x 302
x 304
286
x 284
x 285
x 270
x 271
x 269
268
267
272
x 213
x 214
x 215
x 217


CLEAR
ZONE
SAFETY CLEARANCE
SAFETY CLEARANCE
SAFETY CLEARANCE
SAFETY CLEARANCE
CLEAR
ZONE
E-W RUNWAY 10,000 x 200 INSTRUMENT RUNWAY
E W APRON
E W APRON EXTENSION
HANGAR 3
HUSH HOUSE
HANGAR 4
N-S RUNWAY
TAXIWAY 3
BLAST PAD
OVERRUN
Former Cooling Pond
x 302
x 301
303
x 304
298
x 300
275
x 274
286
x xx 284
285
x 227
x 228
x 225
226
x 223
x 224
x 222
x 221
x 215
x 214
x 213
x 219
x 218
220 x
x 287
N 116,000
N 114,000
N 118,000
N 112,000


CLEAR
ZONE
SAFETY CLEARANCE
SAFETY
CLEARANCE
W RUNWAY CENTERLINE EXTENDED
HANGAR 16
N 118,000
N 116,000
N 114,000
N 112,000
N 110,000
275
x 274
x 305
x 290
x 288
x 291
x 292
x 287
x 289
Ammo Storage Area "B"



GENERAL NOTE

THE COORDINATES AND ELEVATIONS SHOWN HEREON ARE BASED UPON A FIELD SURVEY BETWEEN THE LOCATIONS SHOWN HEREON AND THE ELMENDORF HORIZONTAL AND VERTICAL DATUM AS MONUMENTED AND PUBLISHED BY THE U S DEPARTMENT OF THE AIR FORCE NO FIELD SURVEYS WERE CONDUCTED BETWEEN MONUMENTS TO VERIFY THE PUBLISHED VALUES RELATIVE TO ONE ANOTHER PUBLISHED VALUES FOR THE MONUMENTS, AND THEIR CORRESPONDING POSITIONS, WERE ASSUMED TO BE CORRECT FOR THE PURPOSE OF THIS SURVEY

STATE OF ALASKA
49TH

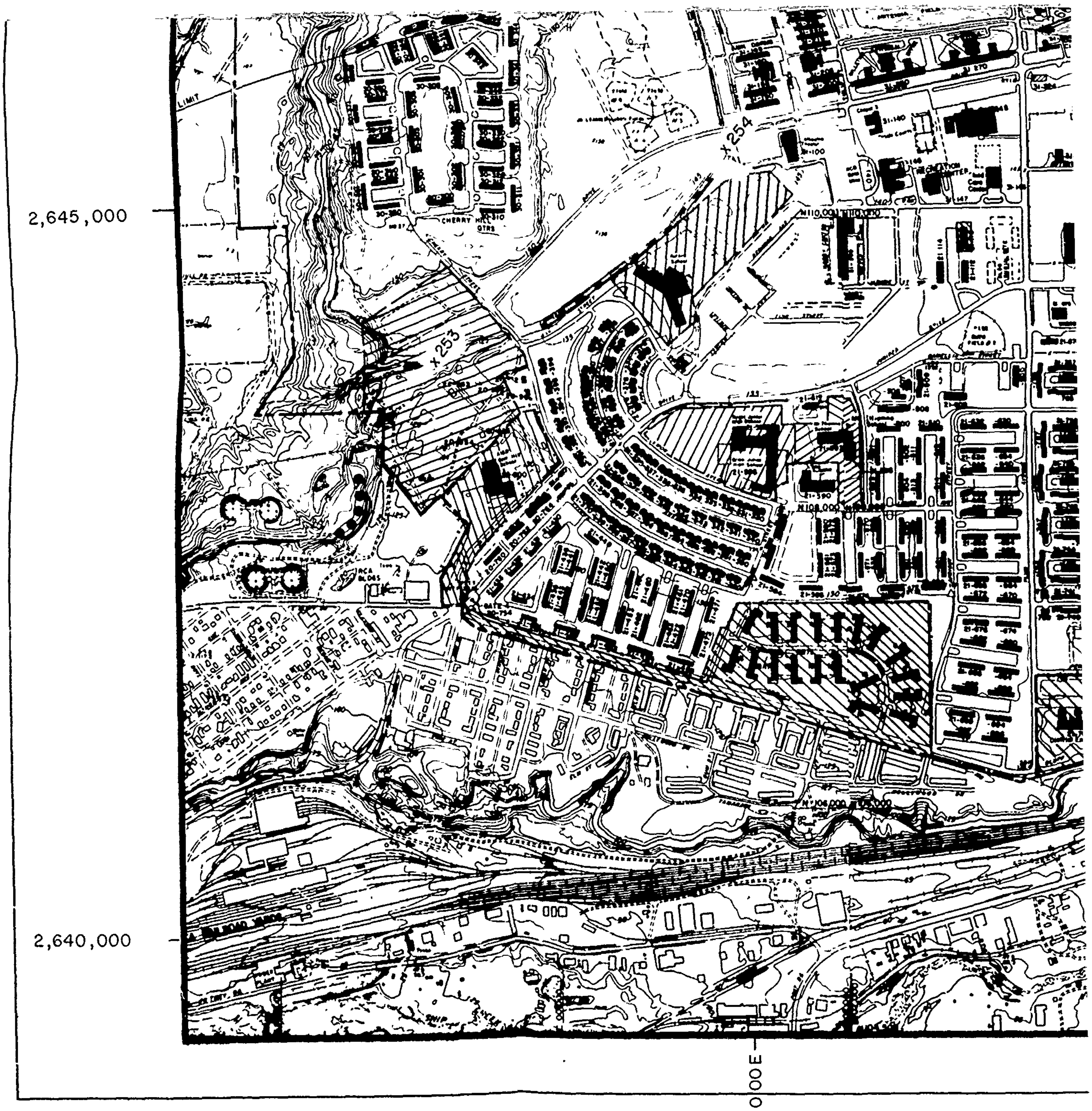
BLACK & VEATCH

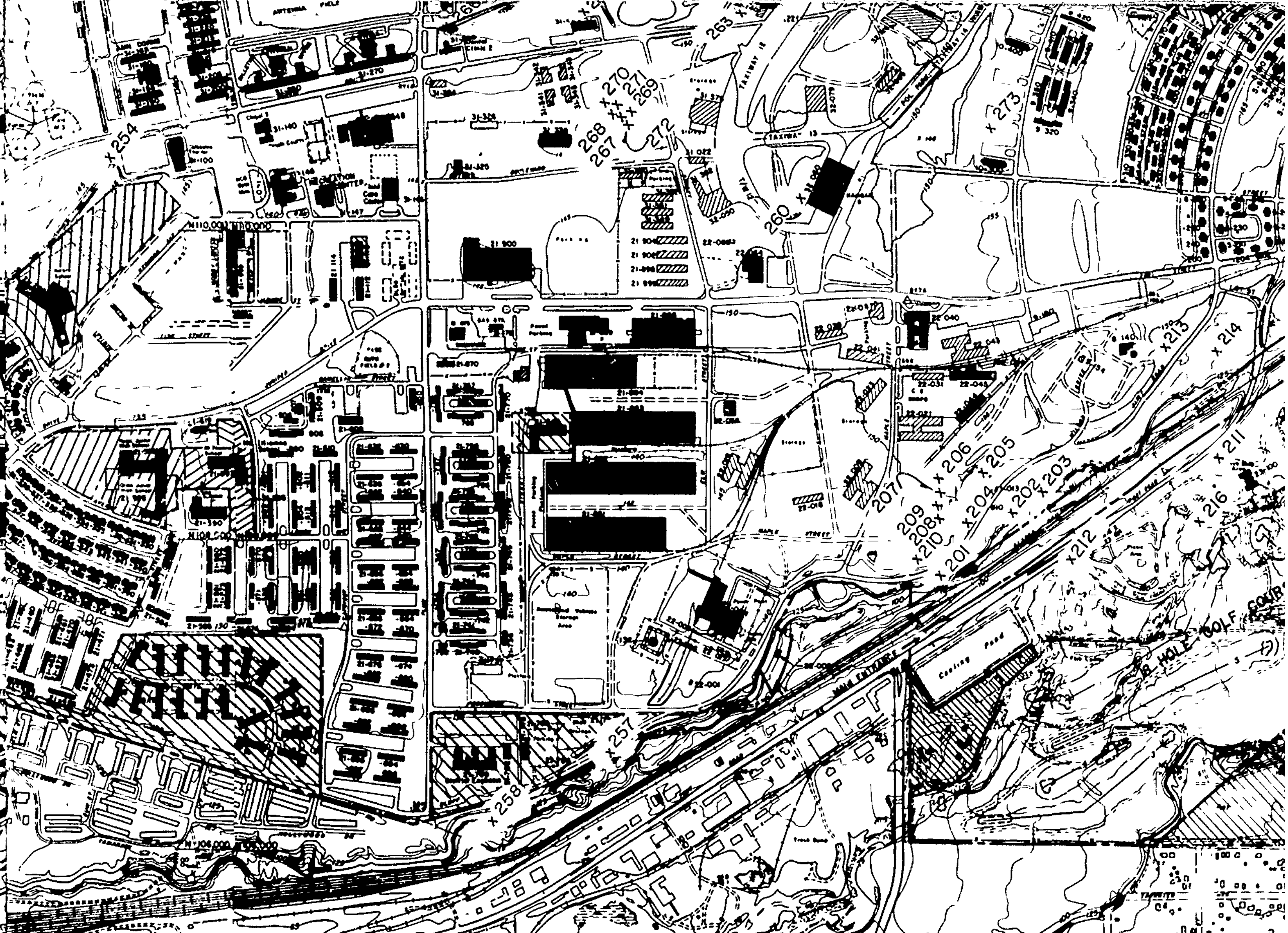
SITE MAP

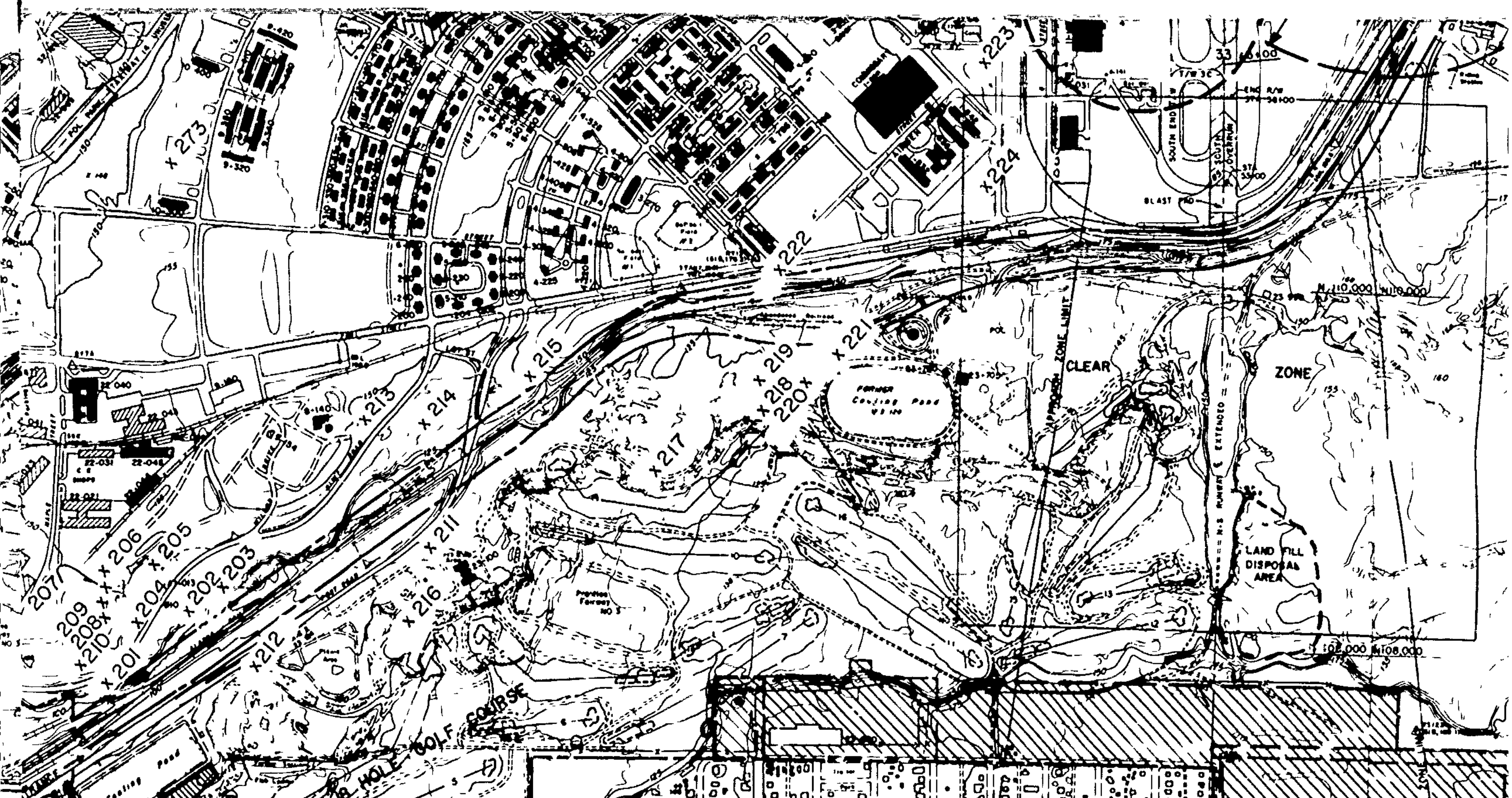
GEOTECHNICAL TESTING SITES ELMENDORF AIRFORCE BASE

L.C.M.F.
ENGINEERS · PLANNERS · SURVEYORS
723 WEST 6TH AVENUE ANCHORAGE, ALASKA

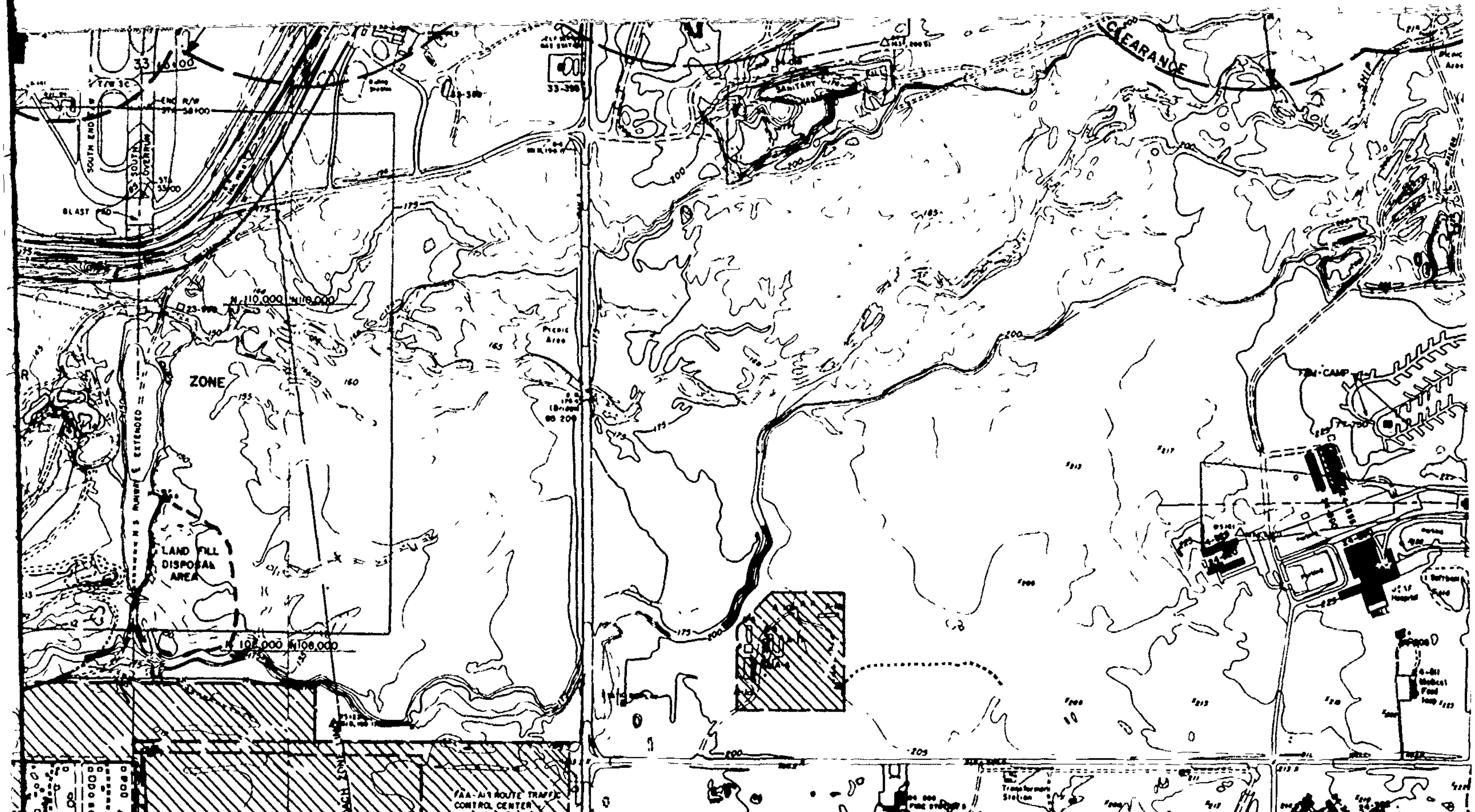
DATE: NOVEMBER 1988	SCALE 1" = 800'

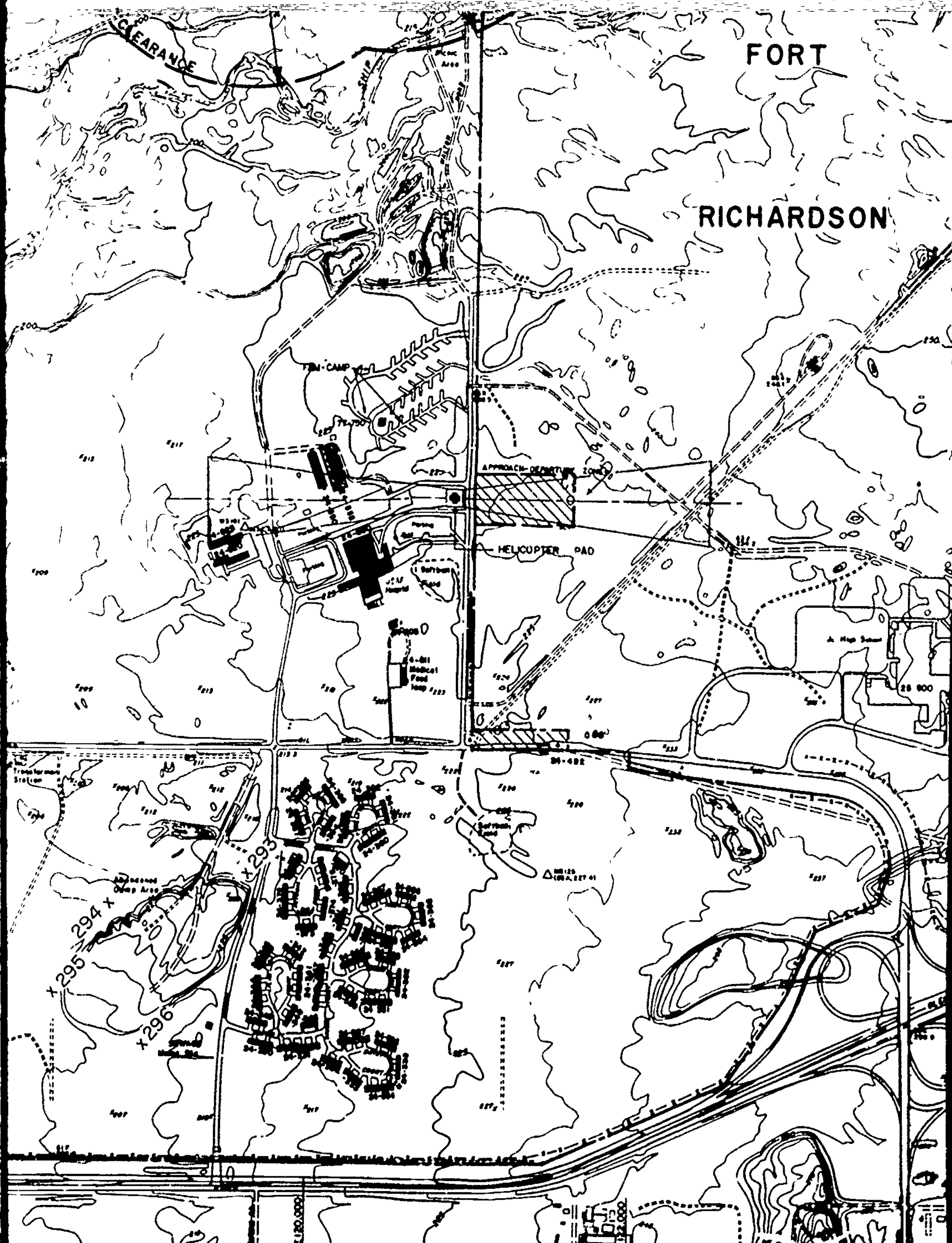

2,645,000
2,640,000
525,000E
X 254
X 253
CHERRY HILL QTRS
RCA BLDGS
LIMIT


x 254
263 x
x 273
268
267
x 270
x 271
x 269
272
260 x
207
209
208
x 210
x 201
x 206
x 205
x 204
x 202
x 203
x 213
x 214
x 211
x 212
x 216
x 257
x 258
Cooling Pond
MAIN ENTRANCE
18 HOLE GOLF COUR
525, 000 E
530,00 0E



Municipality of Anchorage
8 HOLE GOLF COURSE
CLEAR
ZONE
LAND FILL DISPOSAL AREA
Cooling Pond
Former Cooling Pond
x 201
x 202
x 203
x 204
x 205
x 206
207
208x
209
x210
x 211
x212
x 213
x 214
x 215
x 216
x 217
x 218
x 219
220x
x 221
x 222
x 223
x 224
x 273
530,000E
535,000 E


CLEARANCE
ZONE
LAND FILL
DISPOSAL
AREA
N 110,000
N 108,000
N 106,000
FAA AIR ROUTE TRAFFIC
CONTROL CENTER
Transformer Station
x 295
x 294
x 293
x 296
540,000E



545,000E

BLACK & VEA

SITE MAP
GEOTECHNICAL TESTIN
ELMENDORF AIRFORC

L.C.M.F.
ENGINEERS · PLANNERS ·
723 WEST 6TH AVENUE ANC

DATE: NOVEMBER 1988	SCALE 1"=
DRAWN BY: RBC	SHEET: 1 (
CHECKED BY: DH	W. O. No: 88

AIRFIELD ELEVATION
INSTALLATION NO.

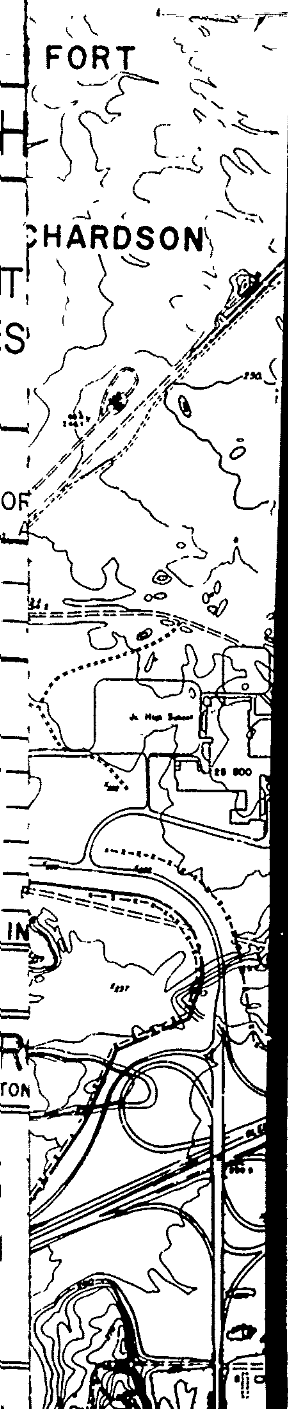
REV	DATE	DESCRIPTION
	30SEP87	UPDATED

PLAN REVISIONS

DEPARTMENT OF THE AI
DIRECTORATE OF CIVIL ENGINEERING DCS/P&R-

ALASKAN AIR COMMA
MASTER PLA
(SMALL SCALE) BASE
IRP STAGE 3 RI/FS
ELMENDORF AFB, AK
BASE MAP

SCALE: 1"=800' DATE:
MASTER PLANNING DIRECTIVE 53-1
U.S. ARMY ENGINEER DISTRICT, ALASKA
ANCHORAGE, ALASKA



BLACK & VEATCH

SITE MAP

GEOTECHNICAL TESTING SITES
ELMENDORF AIRFORCE BASE

L.C.M.F.
ENGINEERS · PLANNERS · SURVEYORS
723 WEST 6TH AVENUE
ANCHORAGE, ALASKA

DATE: NOVEMBER 1988	SCALE 1" = 800'
DRAWN BY: RBC	SHEET: 1 OF 1
CHECKED BY: DH	W. O. No: 88-046

AIRFIELD ELEVATION
INSTALLATION NO.

REV	DATE	DESCRIPTION	INITIAL
	30SEP87	UPDATED	PLC

PLAN REVISIONS

DEPARTMENT OF THE AIR FORCE
DIRECTORATE OF CIVIL ENGINEERING DCS/P&R - WASHINGTON, D. C.

ALASKAN AIR COMMAND
MASTER PLAN
(SMALL SCALE) BASE PLAN
IRP STAGE 3 RI/FS
ELMENDORF AFB, AK
BASE MAP

SCALE: 1" = 800'	DATE:	13833.150
MASTER PLANNING DIRECTIVE 53-1		
U.S. ARMY ENGINEER DISTRICT, ALASKA ANCHORAGE, ALASKA		SHEET 1 OF 2

CORPS OF ENGINEERS

2,660,000

2,655,000

PT. NO.	NORTH	EAST	ELEVATION	DESCRIPTION
201	2,642,638 11	530,414.59	138.54	SP2/6-5
202	2,643,044.10	530,867.20	143.21	SP2/6-4
203	2,643,196.34	531,042.90	144.39	SP2/6-3
204	2,642,988.79	530,585.93	140.83	SP2/6-10
205	2,643,291.16	530,678.56	146.91	SP2/6-2
206	2,643,270 48	530,391.27	155 42	SP2/6-1
207	2,643,133.52	530,438.25	155 73	SP2/6-9
208	2,643,018 52	530,395.57	151.04	SP2/6-8
209	2,643,092 91	530,379 65	151.71	SP2/6-7
210	2,642,737.05	530,257.73	150.47	SP2/6-6
211	2,643,388 95	532,258 09	111.92	NS3-3
212	2,642,743 12	531,239.76	98 99	SC-6
213	2,644,108 79	531,896 10	149 25	NS3-4
214	2,644,092 46	532,225.52	136.84	NS3-5
215	2,644,389 33	532,813.91	149.03	NS3 6
216	2,642,986.00	532,141 85	104.04	SC-5
217	2,643,844.94	533,549.90	121.13	NS3-2
218	2,644,183.95	534,143.52	121.11	SC-4
219	2,644,365.00	534,129.18	126.18	NS3-1
220	2 644,362 75	534,385.14	131 27	SP4-2
221	2,644,617.46	534,608.14	137 36	SP4-1
222	2,644,972.57	534,210 28	173.67	SP4-3
223	2,646,220.91	535,382 82	181 94	SP14-1
224	2,645,490.34	535,396.49	181 26	SP14-2
225	2,648,375.84	535,691.69	185.31	SP13-1
226	2,648,363.00	535,779.95	185 49	SP13-2
227	2,648,607 87	534,348 10	185.03	SP15-1
228	2,648,934 93	534,520.50	184.58	SP15-2
229	2,649,090 21	524,446.60	253.77	SP5A-16
230	2,649,078.58	524,299 41	252.51	SP5A-15
231	2,649,113 90	524,875 06	236.68	SP5A-19
232	2,649,086 69	524,432 20	251.90	UPPER TRENCH
233	2,649,043 33	524,095 83	242.56	SP5A-14
234	2,649,147 43	524,741.74	243 00	SP5A-18
235	2,649,112 63	524,594.19	241.21	SP5A-17
236	2,649,039 38	524,461.09	229.30	LOWER TRENCH
237	2,649,607 86	524,859 61	266 28	SP5 5
238	2,649,164 16	524,461 17	268 43	SP5-7
239	2,649,377 96	524,708.31	268 86	SP5 6
240	2,649,412 47	524,552 52	279.97	SP5 1
241	2,649,401.16	524,247.13	[illegible]	SP5-2
242	2,649,409.59	524,427.83	271 99	SP5-9
243	2,649,556.29	524,257.14	261 57	SP5-3
244	2,649,513.98	524,499 63	256 81	SP5 4
245	2,649,340 52	524,102.69	262 20	SP5-11
246	2,649,388 85	523,995 41	260 30	SP5-12
247	2,649,638 51	524,045.48	234 40	SP5-13
248	2,649,832 41	524,319 42	235.14	SP5-10
249	2,649,841 63	524,011 32	219 09	SP5-20
250	2,649,838 69	524,148 07	249 79	SP5 8
251	2,648,595 39	522,528 95	188.99	D15 01
252	2,648,734 87	522,521 09	187.41	D15 02
253	2,643,895 66	522,805 63	106.76	NS1-4
254	2,645,316 63	524,862 18	128 54	NS1-3
255	[illegible],645,452 06	525 258 31	145 38	BH-6
256	2,647,072 35	525,723 08	141.79	NS1-2
257	2,641,508 93	528,222.29	138 34	SP1-2
258	2,641,060.72	527,410.51	100.69	SP1-1
259	2,646,518.84	528,598.90	151 05	D17-4

PT. NO.	NORTH	EAST	ELEVATION
260	2,645,073.3[illegible]	529,473.18	154 53
261	2,646,849.34	529,351.14	155 50
262	2,647,287.30	529,170.92	156.14
263	2,646,333.37	529,073.41	154.14
264	2,646,329.66	528,023.81	148.56
265	2,646,946.36	527,530.25	151 40
266	2,646,193.38	527,106 23	139.37
267	2,645,611.45	528,270.52	144 80
268	2,645,594.34	528,219 73	144 75
269	2,645,624.35	528,328.10	144.61
270	2,645,636.71	528,213.63	145 61
271	2,645,652.95	528,263.91	146.51
272	2,645,580.34	528,280.44	144.18
273	2,645,536.33	530,730.73	157.77
274	2,652,204 81	539,309.33	216.09
275	2,652,636.05	539,119.39	215 76
276	2,655,537.28	538,119.94	248.90
277	2,658,175.29	539,592.95	273.29
278	2,658,040.08	539,455.08	274 87
279	2,658,051 86	539,383.19	275 30
280	2,658,018 98	539,205 45	277 65
281	2,656,448 04	534,545 68	318 27
282	2,652,367 93	528,949 22	303 19
283	2,651,407.02	526,682.84	245 08
284	2,648,328 09	532,279.44	176.60
285	2,648,317.94	532,268.46	176.50
286	2,648,275 21	532,220 05	176 17
287	2,646,874.26	539,796.84	207 63
288	2,647,568.04	539,978 76	210 96
289	2,646,939 46	540,442 46	205 29
290	2,647,807 69	540,044 44	210 76
291	2,648,113 78	540,716 44	211 34
292	2,647,880 72	541,053 91	214.85
293	2,641,583 53	543,282 68	224.08
294	2,641,415 22	542,447.15	208 35
295	2,640,874 85	542,108 47	205.60
296	2,640,587 91	542,662 31	208 15
297	2,650,588.76	530,874 62	177 04
298	2,650,591 81	531,338 03	181 46
299	2,649,762 40	531,209 09	169 28
300	2,649,821.84	531,512 66	170.95
301	2,651,785 52	533,105 08	188 23
302	2,652,523 64	532,814 01	189 83
303	2,652,935 05	534,944 81	202 73
304	2,651,001 54	532,237 07	181 70
305	2,650,891 03	541,394 13	230.34

NOTES

1 THE COORDINATES LISTED ABOVE ARE ALASKA STATE PLAN
THE BASIS OF THESE COODINATES IS THE USC & GS STATION
THE POINT OF ORIGIN FOR THE ELMENDORF COORDINATE SYST
AND 110,000 EAST THE THEATA ANGLE AT THIS STATION IS
SCALE FACTOR IS 0 9999013

2 THE ELEVATION LISTED ARE MEAN SEA LEVEL

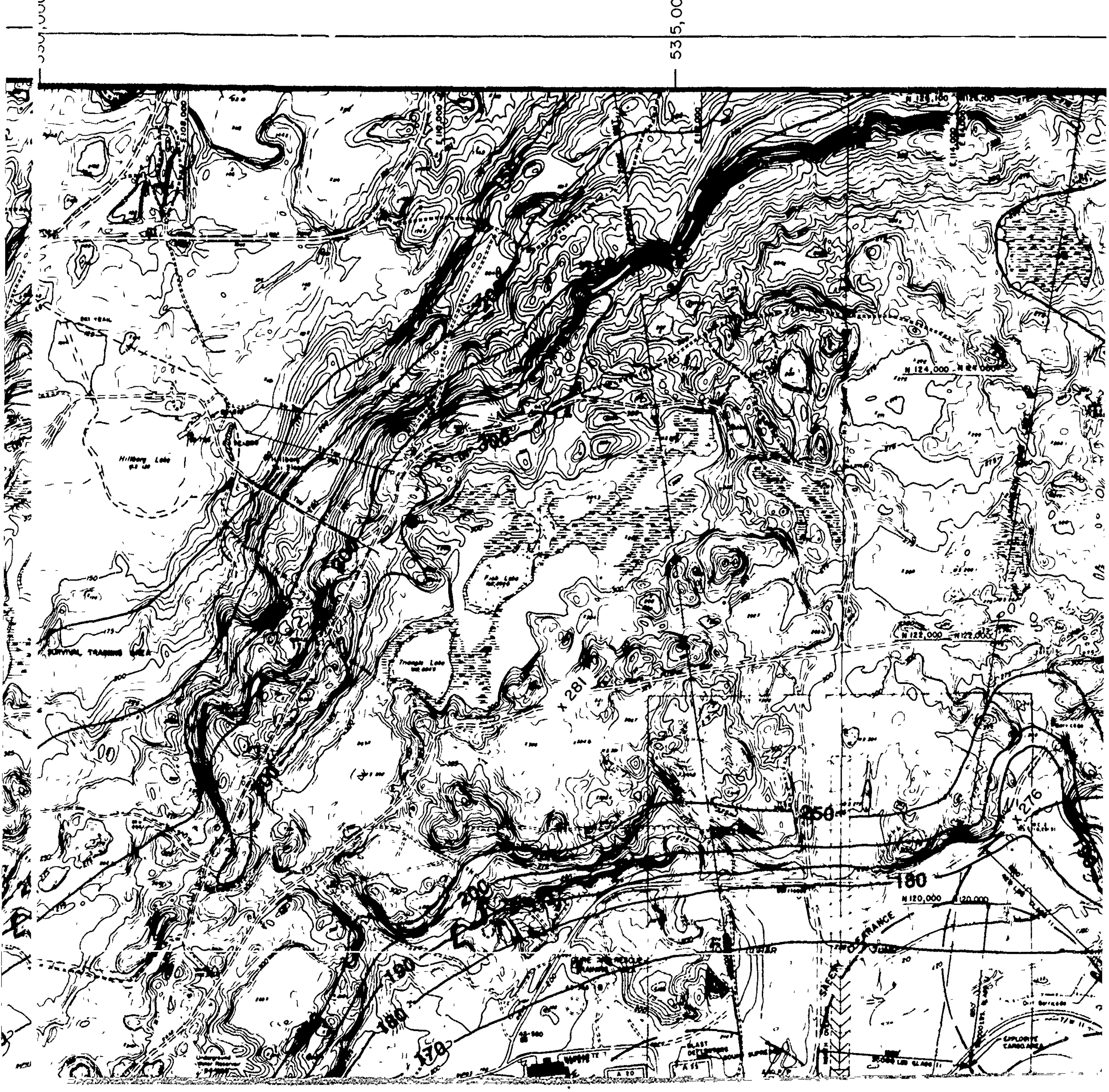
ON

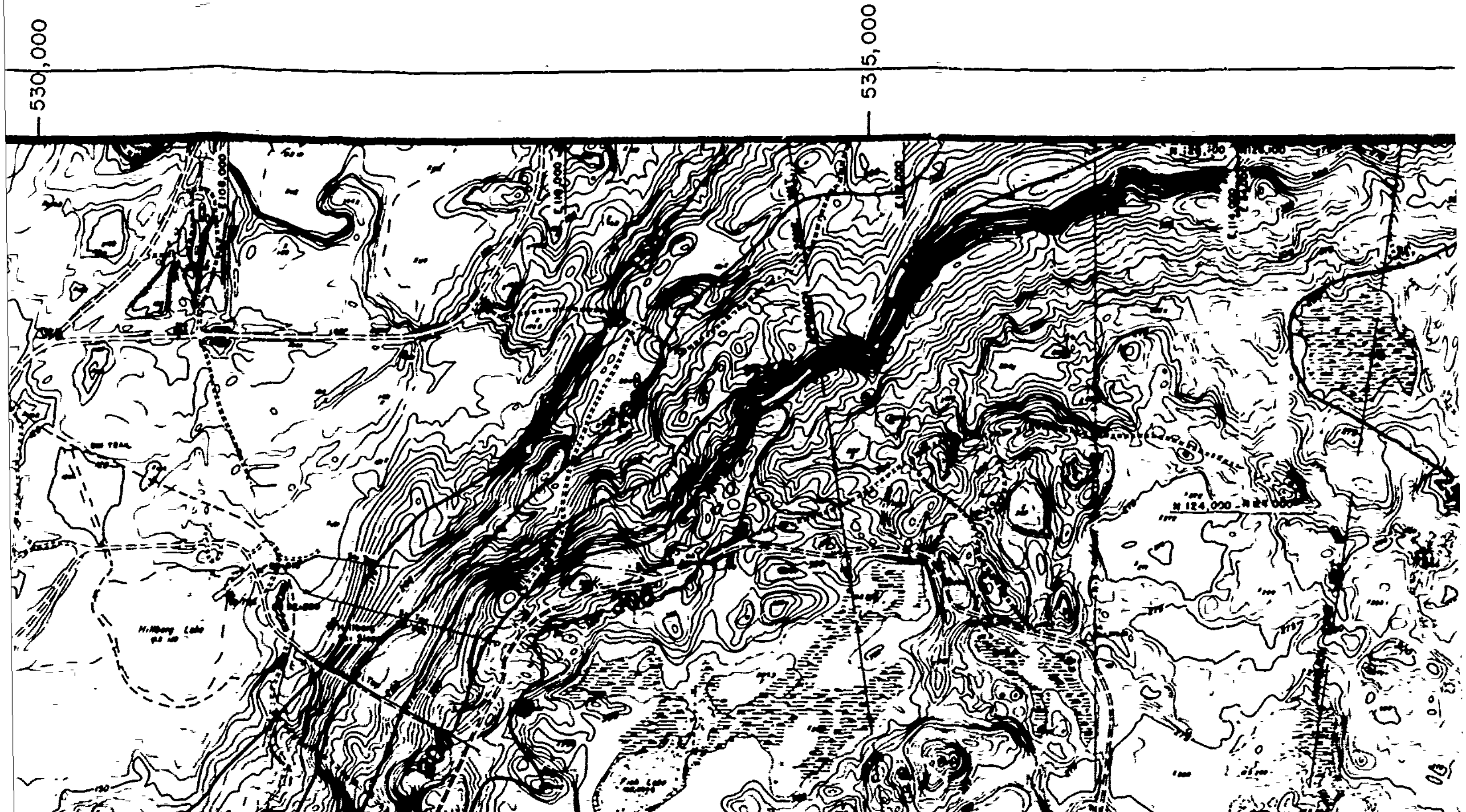
PT. NO.	NORTH	EAST	ELEVATION	DESCRIPTION
260	2,645,073.31	529,473.18	154.53	IS 8
261	2,646,849.34	529,351 14	155 50	D17-2
262	2,647,287.30	529,170.92	156.14	D17-3
263	2,646,333 37	529,073.41	154.14	D17-1
264	2,646,329.66	528,023.81	149 56	D17-5
265	2,646,946.36	527,530.25	151.40	D17-6
266	2,646,193.38	527,106.23	139.37	NS1-1
267	2,645,611.45	528,270.52	144 80	S6-1
268	2,645,594.34	528,219.73	144.75	S6-2
269	2,645,624.35	528,328.10	144 61	S6-3
270	2,645,636.71	528,213.63	145.61	S6-4
271	2,645,652.95	528,263.91	146.51	S6-5
272	2,645,580 34	528,280 44	144.18	S6-6
273	2,645,536.33	530,730.73	157.77	ABORTED PUMP TEST
274	2,652,204.81	539,309 33	216.09	IS-5
275	2,652,636 05	539,119.39	215.76	IS-6
276	2,655,537.28	538,119 94	248.90	BH-2
277	2,658,175.29	539,592.95	273.29	D16-3
278	2,658,040.08	539,455 08	274.87	D16-1
279	2,658,051.86	539,383 19	275 30	D16 2
280	2,658,018.98	539,205.45	277.65	D16-4
281	2,656,448.04	534,545.68	318.27	BH 3
282	2,652,367 93	528,949 22	303.19	BH-4
283	2,651,407.02	526,682 84	245 08	BH 5
284	2,648,328 09	532,279 44	176 60	PT-1
285	2,648,317 94	532,268.46	176.50	PT-3
286	2,648,275.21	532,220.05	176.17	PT-4
287	2,646,874.26	539,796.84	207.63	D13-3
288	2,647,568.04	539,978.76	210.96	D13 2
289	2,646,939.46	540,442 46	205.29	D13 4
290	2,647,807 69	540,044.44	210.76	NS2 2
291	2,648,113 78	540,716 44	211 34	NS2-1
292	2,647,880 72	541,053 91	214.85	D13-1
293	2,641,583.53	543,282 68	224 08	D3-1
294	2,641,415.22	542,447 15	208 35	D3-2
295	2,640,874.85	542,108.47	205.60	D3 3
296	2,640,587 91	542,662 31	208 15	D3 4
297	2,650,588 76	530,874 62	177 04	SP7/10-4
298	2,650,591 81	531,338.03	181 46	SP7/10-3
299	2,649,762 40	531,209 09	169 28	SP7/10-1
300	2,649,821.84	531,512 66	170 95	SP7/10-2
301	2,651,785 52	533,105 08	188 23	IS 1
302	2,652,523 64	532,814 01	189 83	IS-2
303	2,652,935 05	534,944.81	202 73	IS-3
304	2,651,001 54	532,237.07	181 70	IS-4
305	2,650,891 03	541,394 13	230.34	BH-1

ES

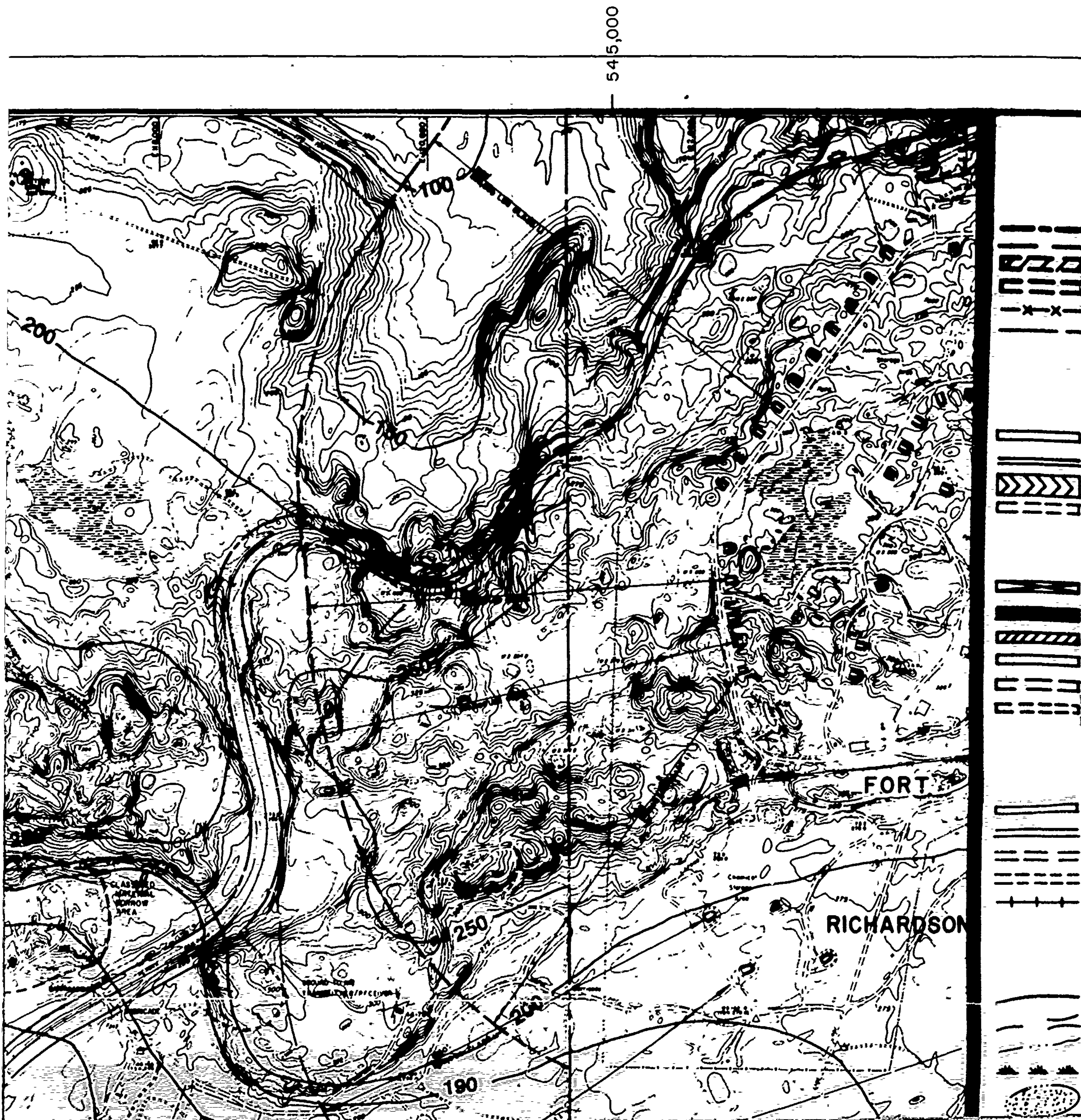
COORDINATES LISTED ABOVE ARE ALASKA STATE PLANE COORDINATES, ZONE 4
BASIS OF THESE COODINATES IS THE USC & GS STATION "TT AN 7 USE" WHICH IS
POINT OF ORIGIN FOR THE ELMENDORF COORDINATE SYSTEM AT 110,000 NORTH
10 000 EAST THE THEATA ANGLE AT THIS STATION IS +0° 10' 03" AND THE
E FACTOR IS 0 9999013

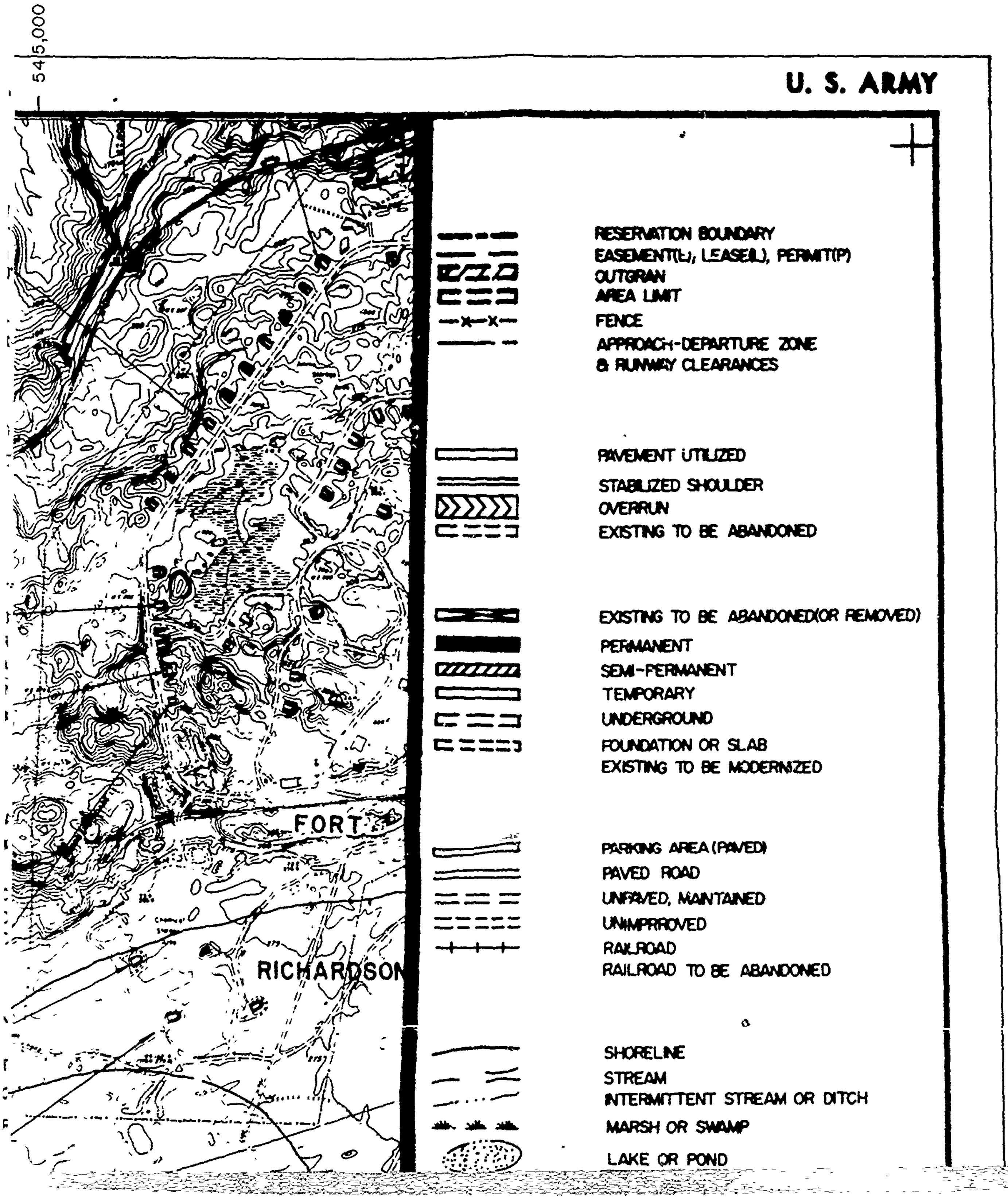
ELEVATION LISTED ARE MEAN SEA LEVEL.


535,000
SURVIVAL TRAINING AREA
N 124,000
N 122,000
N 120,000
X 281
250
180
170
190
200


530,000
535,000
N 124,000
N 122,000
N 120,000
281
250
180
276

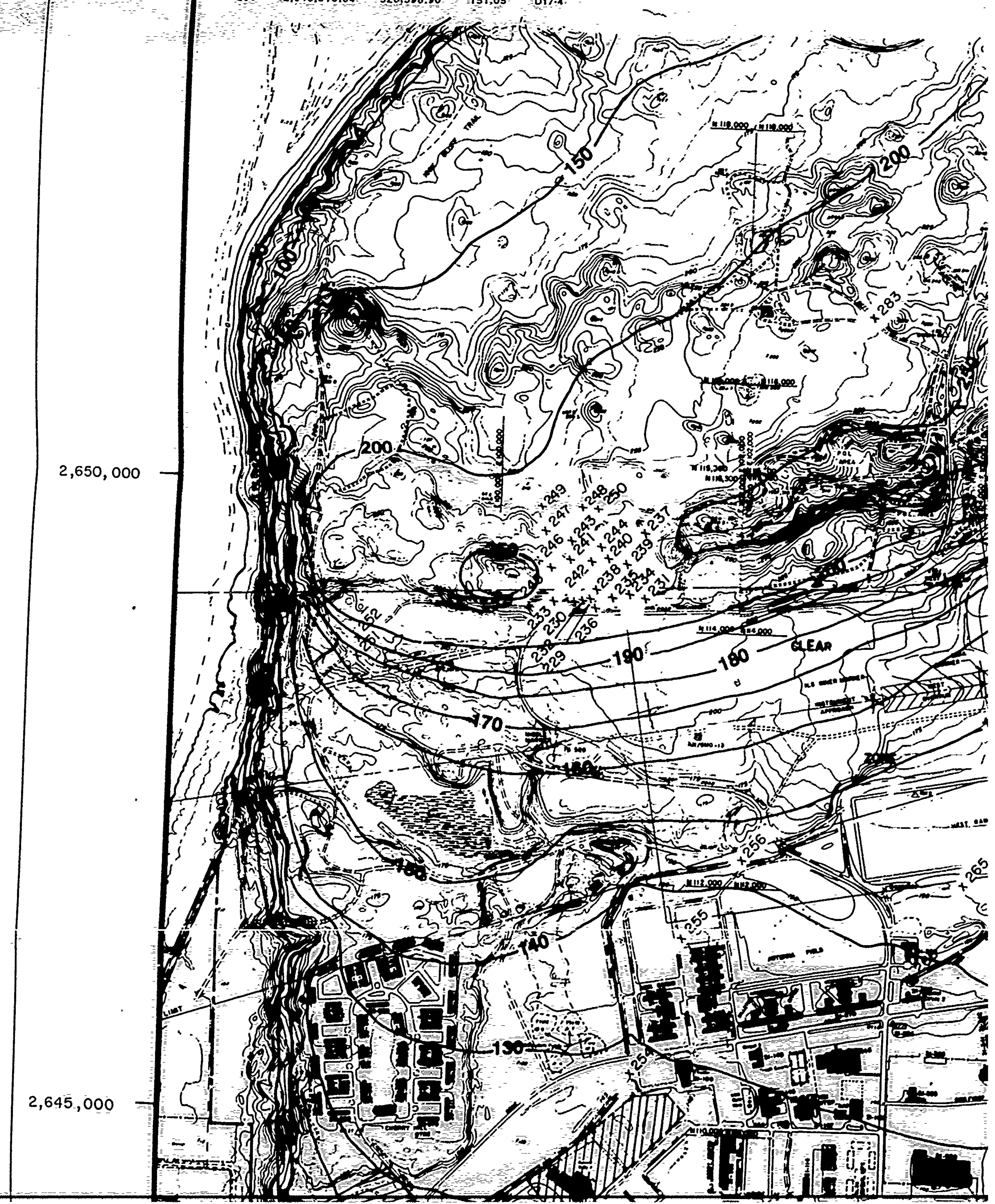

535,000
540,000
200
100
180
170
190
276
N 124,000
N 122,000
N 120,000

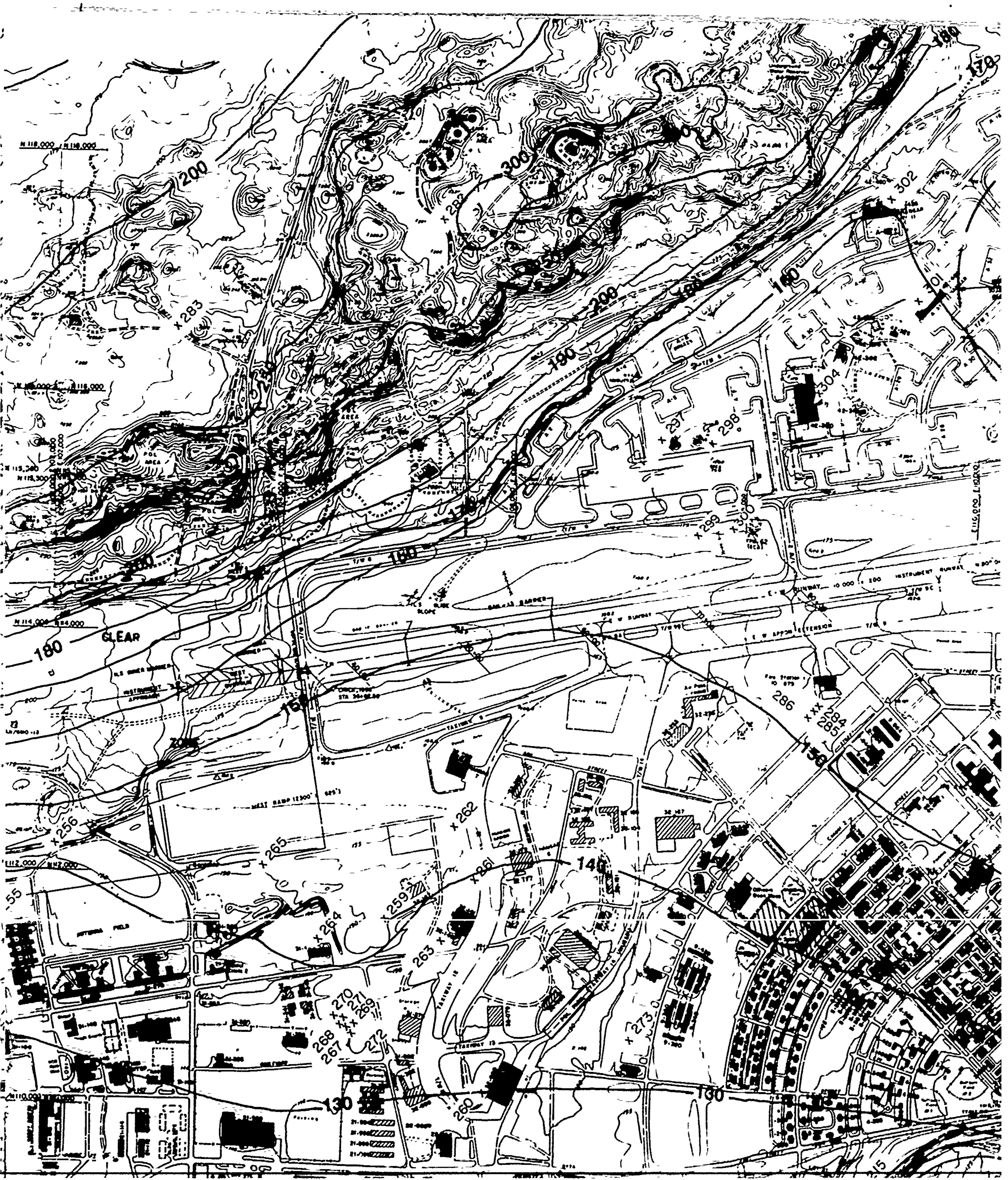

545,000
100
200
FORT
RICHARDSON
250
190



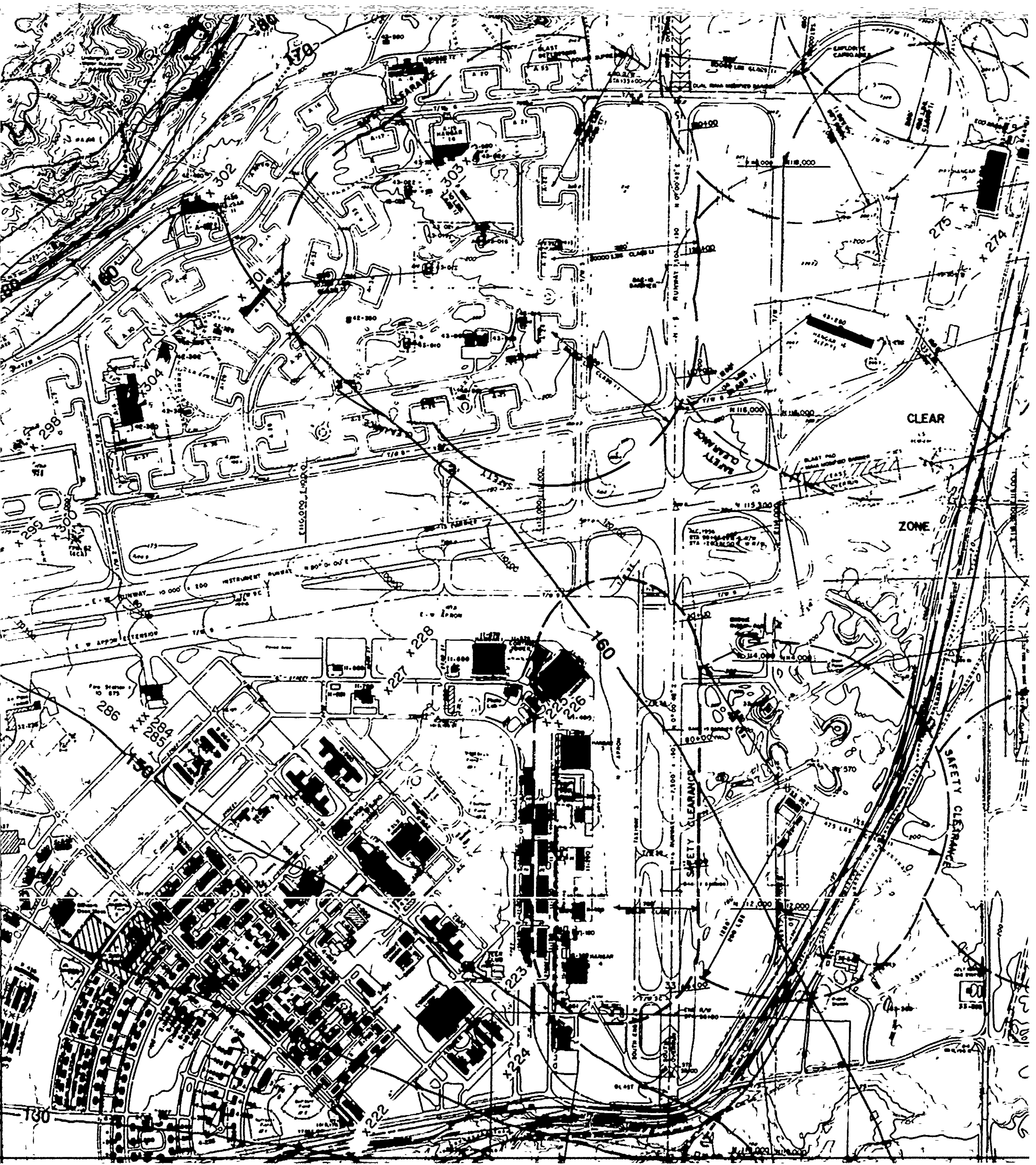
545,000
U. S. ARMY
FORT
RICHARDSON
RESERVATION BOUNDARY
EASEMENT(E), LEASE(L), PERMIT(P)
OUTGRAN
AREA LIMIT
FENCE
APPROACH-DEPARTURE ZONE
& RUNWAY CLEARANCES
PAVEMENT UTILIZED
STABILIZED SHOULDER
OVERRUN
EXISTING TO BE ABANDONED
EXISTING TO BE ABANDONED(OR REMOVED)
PERMANENT
SEMI-PERMANENT
TEMPORARY
UNDERGROUND
FOUNDATION OR SLAB
EXISTING TO BE MODERNIZED
PARKING AREA (PAVED)
PAVED ROAD
UNPAVED, MAINTAINED
UNIMPRROVED
RAILROAD
RAILROAD TO BE ABANDONED
SHORELINE
STREAM
INTERMITTENT STREAM OR DITCH
MARSH OR SWAMP
LAKE OR POND

258	2,641,060.72	527,410.51	100.69	SP1-1
259	2,646,518.84	528,398.90	151.05	D17-4

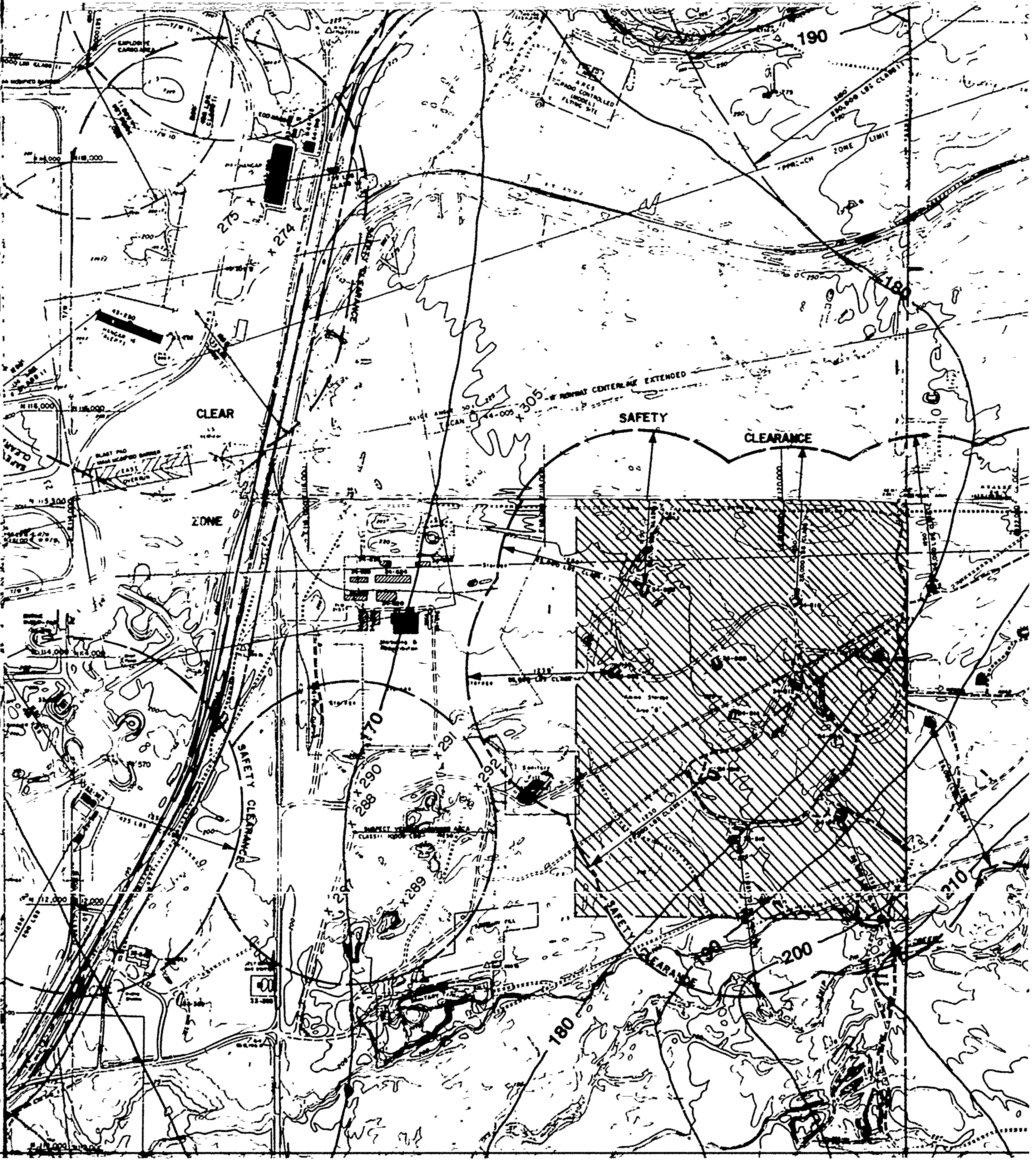


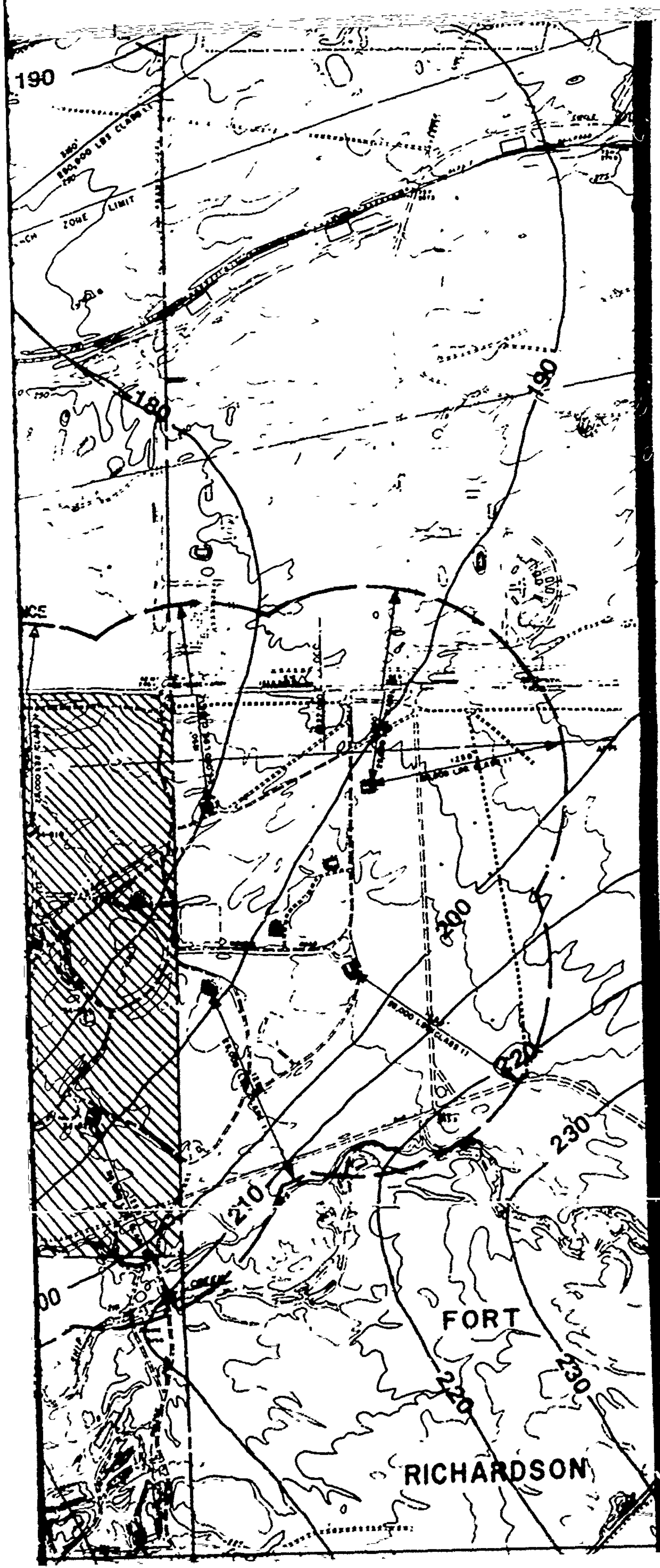


200
300
x 283
x 282
190
180
160
x 302
x 301
x 304
x 297
x 298
x 299
180
CLEAR
200
150
x 256
x 265
x 262
x 261
140
x 259
x 264
x 263
286
x 284
x 285
x 270
x 271
x 269
268
267
272
x 273
130
260
130
170



170
160
150
130
CLEAR
ZONE
SAFETY CLEARANCE
SAFETY CLEARANCE
SAFETY CLEARANCE
x 302
303
x 301
304
x 298
275
x 274
x 227
x 228
225
226
286
284
285
223
x 224
222


190
ZONE LIMIT
CLEAR
ZONE
SAFETY
CLEARANCE
RUNWAY CENTERLINE EXTENDED
305
275
274
180
170
291
290
292
288
289
SAFETY CLEARANCE
SAFETY
CLEARANCE
190
200
210
180



INTERMITTENT STREAM OR DITCH

MARSH OR SWAMP

LAKE OR POND

GENERAL NOTE

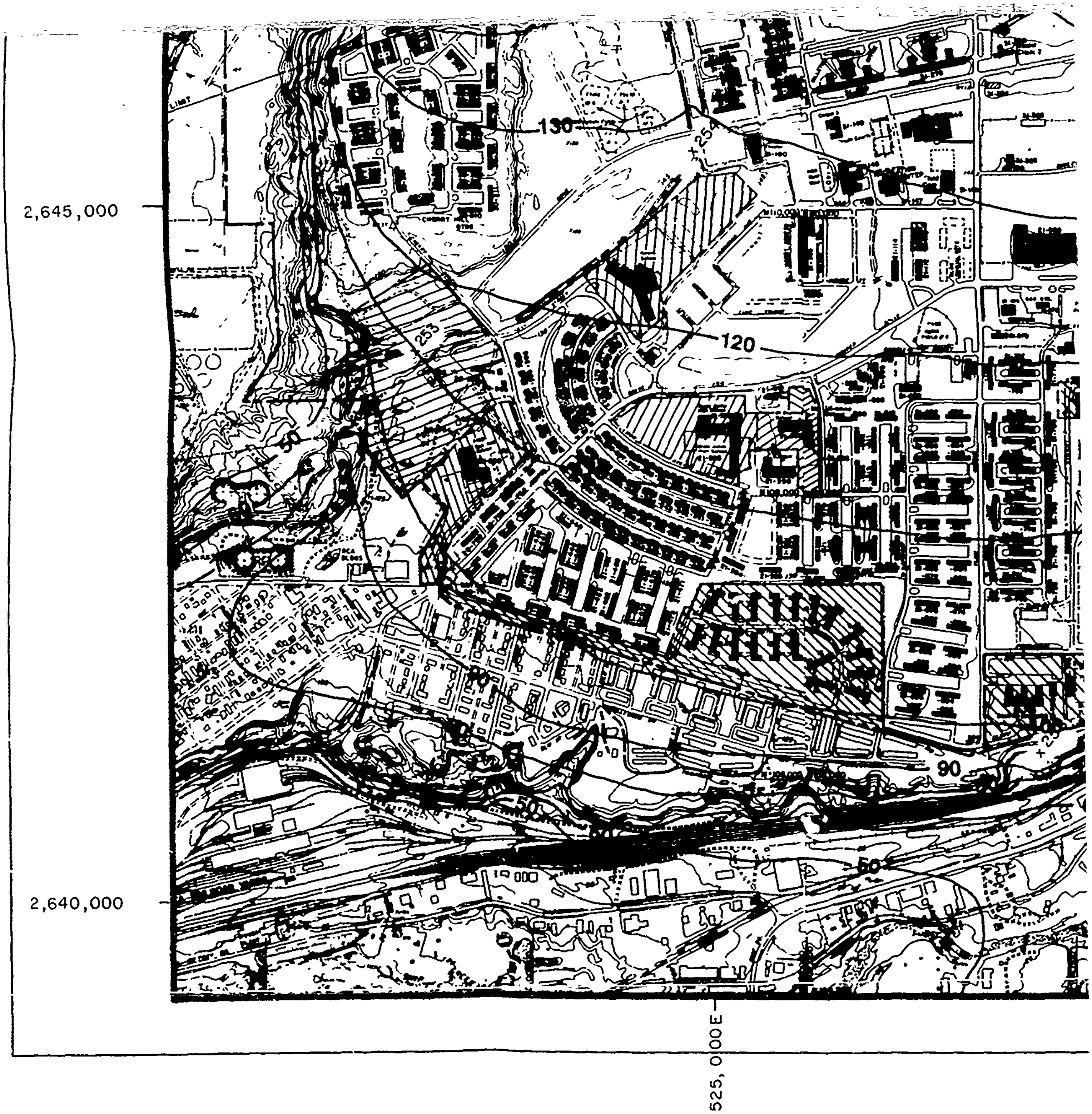
THE COORDINATES AND ELEVATIONS SHOWN HEREON ARE BASED UPON A FIELD SURVEY BETWEEN THE LOCATIONS SHOWN HEREON AND THE ELMENDORF HORIZONTAL AND VERTICAL DATUM AS MONUMENTED AND PUBLISHED BY THE U S DEPARTMENT OF THE AIR FORCE. NO FIELD SURVEYS WERE CONDUCTED BETWEEN MONUMENTS TO VERIFY THE PUBLISHED VALUES RELATIVE TO ONE ANOTHER PUBLISHED VALUES FOR THE MONUMENTS, AND THEIR CORRESPONDING POSITIONS, WERE ASSUMED TO BE CORRECT FOR THE PURPOSE OF THIS SURVEY

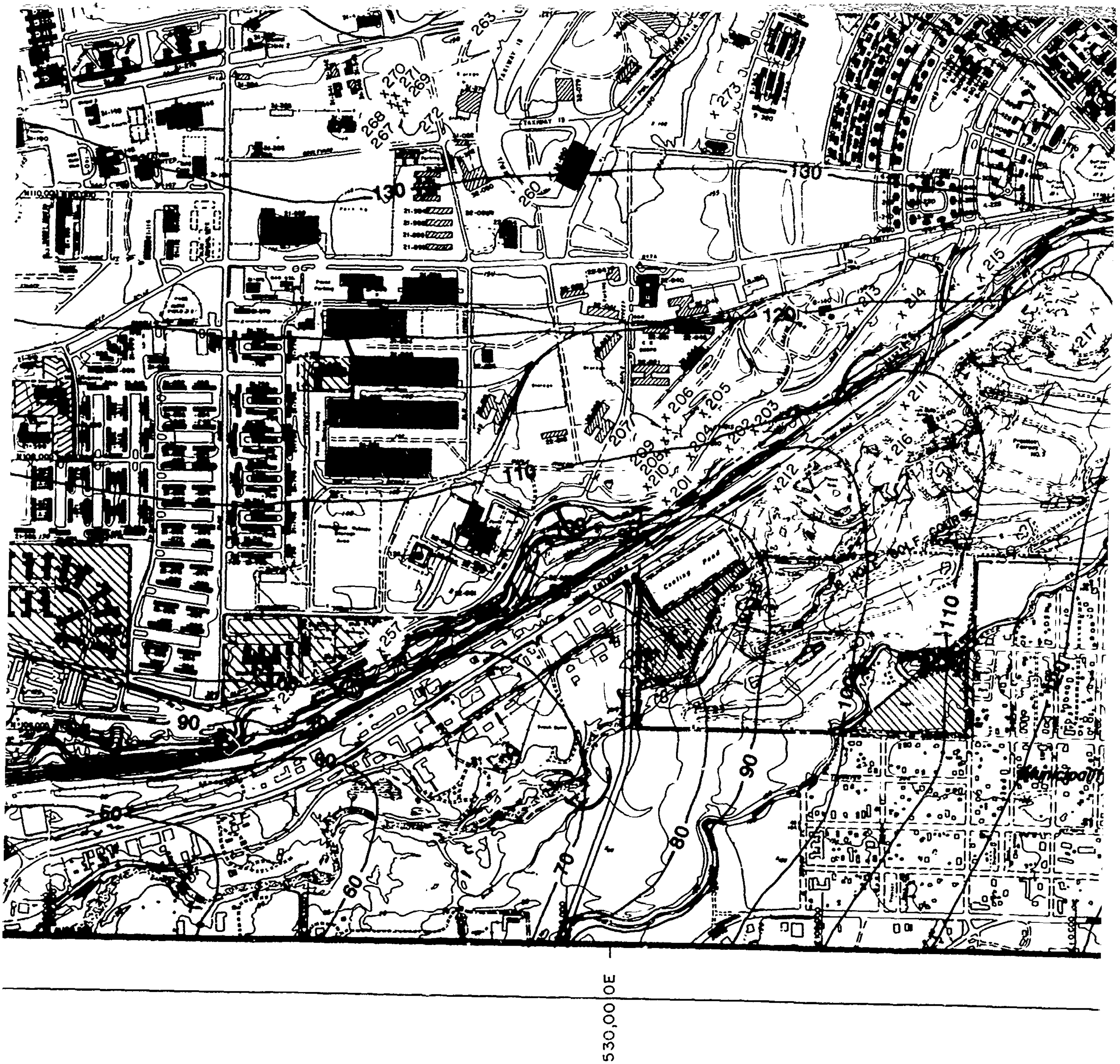
STATE OF ALASKA
49TH
Stephen W. Chronic
LS-5045
REGISTERED PROFESSIONAL LAND SURVEYOR

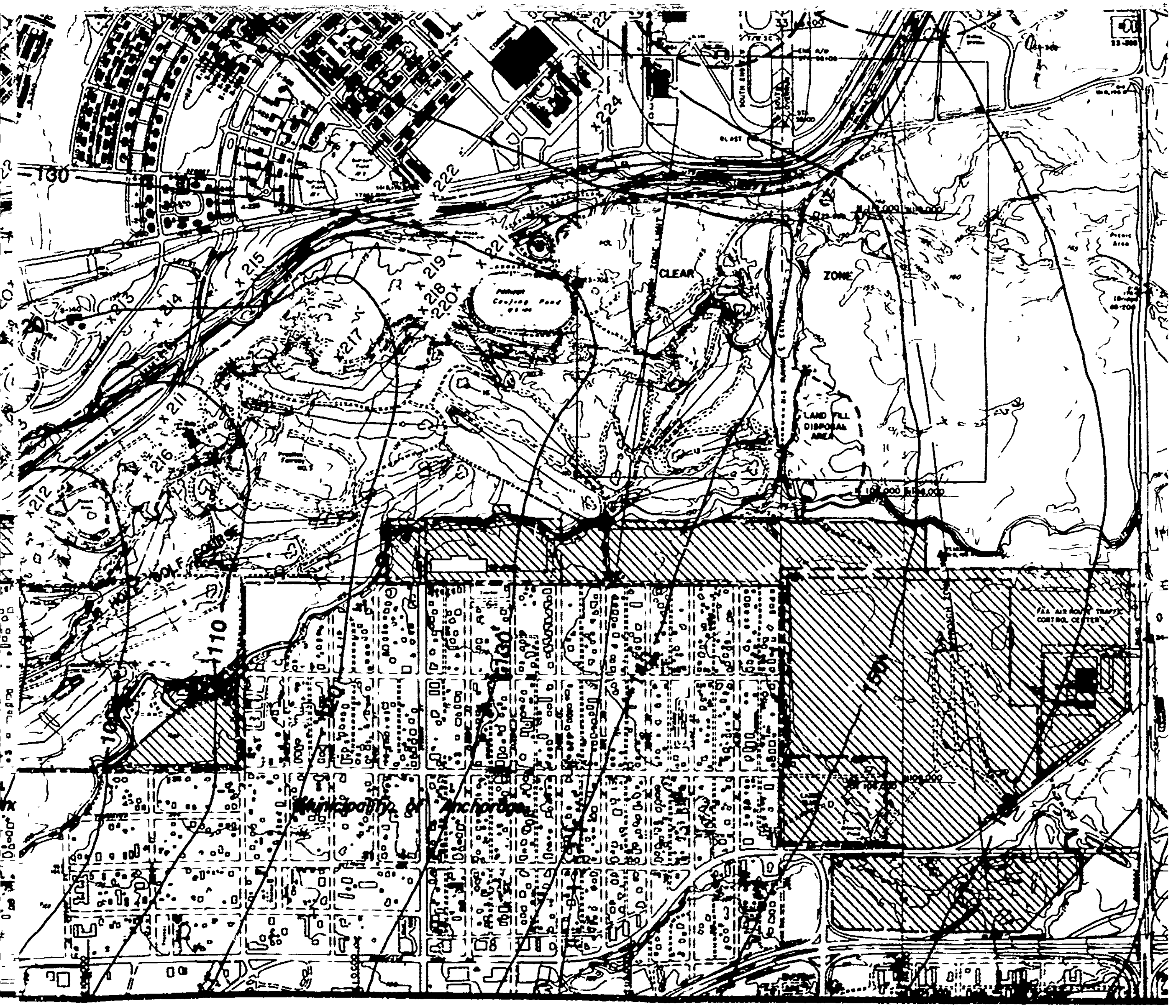
BLACK & VEATCH

SITE MAP

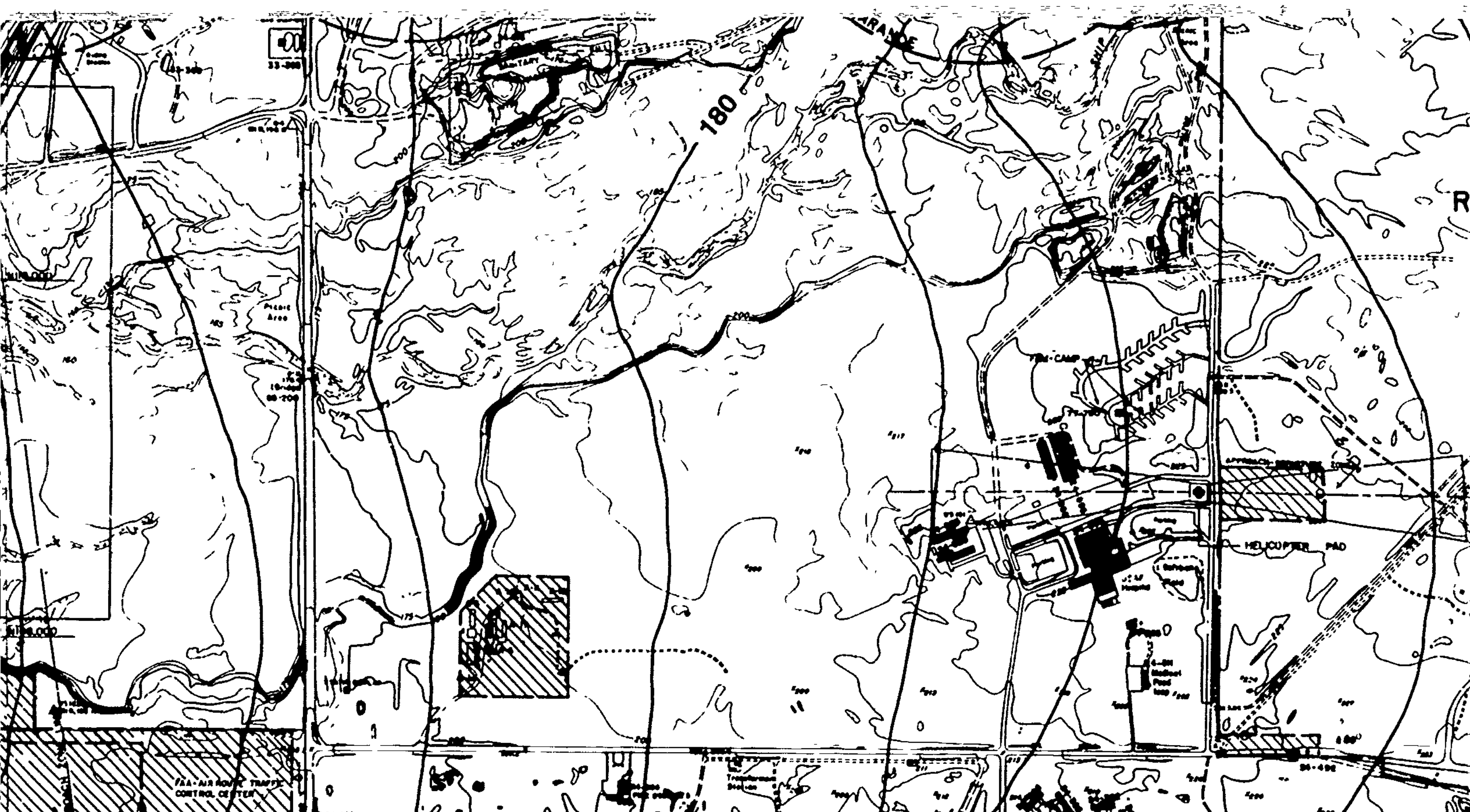
GEOTECHNICAL TESTING SITES
ELMENDORF AIRFORCE BASE


2,645,000
2,640,000
525,000E
130
120
90
50

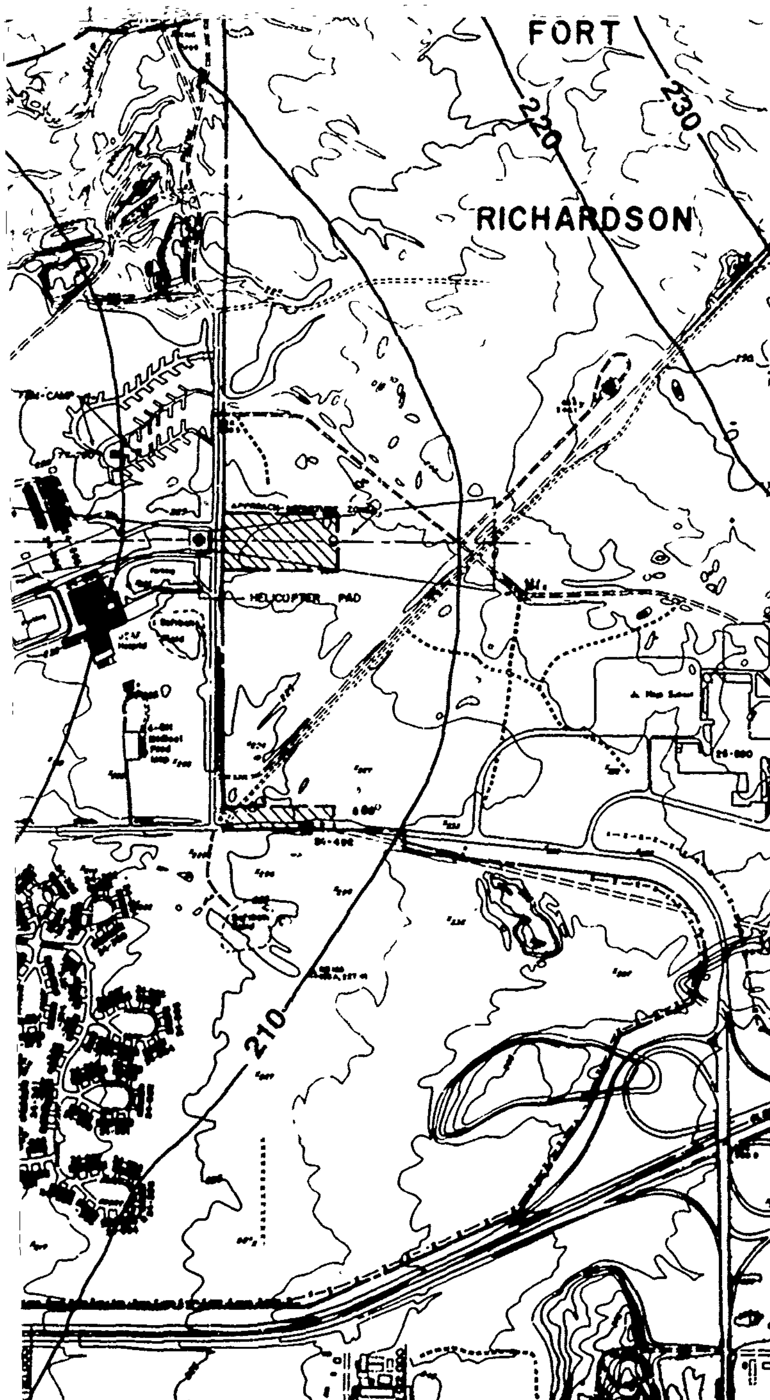

130
120
110
90
80
70
60
50
Cooling Pond
530,000E


CLEAR
ZONE
LAND FILL
DISPOSAL
AREA
Municipality of Anchorage
130
110

535,000 E



180
170
180
190
200
210
HELICOPTER PAD
FAA-AIR ROUTE TRAFFIC CONTROL CENTER
540,000E
545,000E



545,000 E

BLACK & VEATCH

SITE MAP

GEOTECHNICAL TESTING SITES
ELMENDORF AIRFORCE BASE

L.C.M.F.
ENGINEERS · PLANNERS · SURVEYORS
723 WEST 6TH AVENUE ANCHORAGE, ALASKA

DATE: NOVEMBER 1988	SCALE 1" = 800'
DRAWN BY: RBC	SHEET: 1 OF 1
CHECKED BY: DH	W. O. No: 88 - 046

AIRFIELD ELEVATION
INSTALLATION NO.

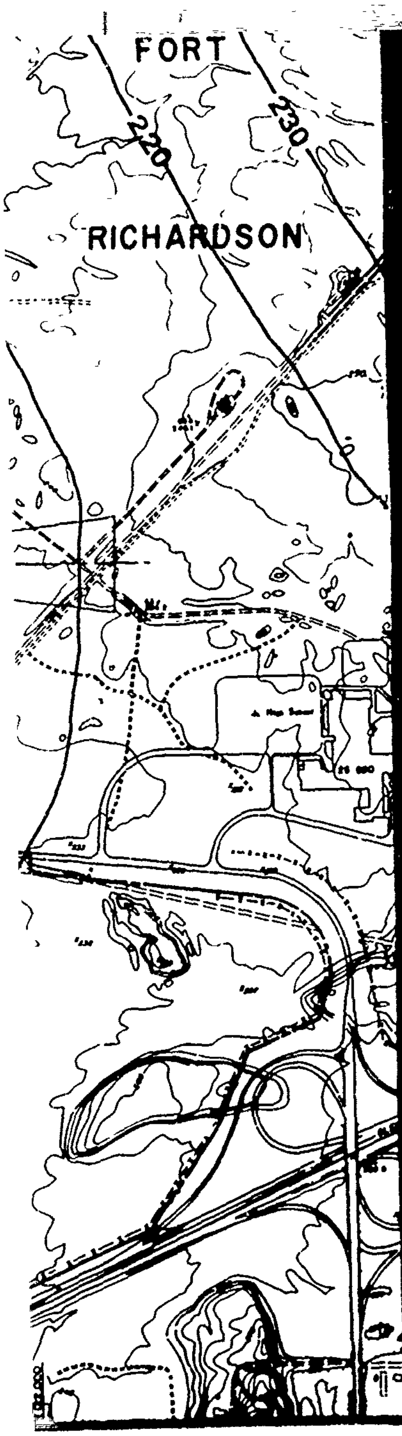
REV	DATE	DESCRIPTION	INITIAL
	30SEP87	UPDATED	PLC

PLAN REVISIONS

DEPARTMENT OF THE AIR FORCE
DIRECTORATE OF CIVIL ENGINEERING DCS/P&R - WASHINGTON, D. C.

ALASKAN AIR COMMAND
MASTER PLAN
(SMALL SCALE) BASE PLAN
IRP STAGE 3 RI/FS
ELMENDORF AFB, AK
BASE HYDROGEOLOGY

SCALE: 1" = 800'	DATE:	13833.150
MASTER PLANNING DIRECTIVE 53-1		SHEET 2 OF 2
U.S. ARMY ENGINEER DISTRICT, ALASKA ANCHORAGE, ALASKA		



BLACK & VEATCH

SITE MAP

GEOTECHNICAL TESTING SITES
ELMENDORF AIRFORCE BASE

L.C.M.F.
ENGINEERS · PLANNERS · SURVEYORS
723 WEST 6TH AVENUE ANCHORAGE, ALASKA

DATE: NOVEMBER 1988	SCALE 1" = 800'
DRAWN BY: RBC	SHEET: 1 OF 1
CHECKED BY: DH	W. O. No: 88-046

AIRFIELD ELEVATION
INSTALLATION NO.

REV	DATE	DESCRIPTION	INITIAL
	30SEP87	UPDATED	PLC

PLAN REVISIONS

DEPARTMENT OF THE AIR FORCE

DIRECTORATE OF CIVIL ENGINEERING DCS/P&R-WASHINGTON, D. C.

ALASKAN AIR COMMAND

MASTER PLAN

(SMALL SCALE) BASE PLAN

IRP STAGE 3 RI/FS
ELMENDORF AFB, AK
BASE HYDROGEOLOGY

SCALE: 1"=800'	DATE:
MASTER PLANNING DIRECTIVE 53-1	13833.150
U.S. ARMY ENGINEER DISTRICT, ALASKA ANCHORAGE, ALASKA	SHEET 2 OF 2